SAE Journal

APRIL 1957

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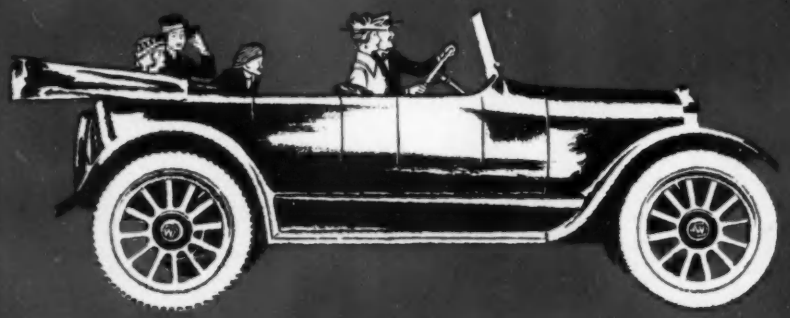
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Published by The Society of Automotive Engineers

WHEN COMPRESSION RATIOS WERE 3 TO 1

...any good oil ring would do!



Back in 1916, this Willys-Knight could be all yours for $1,285. Powered by the famous Willys-Knight sleeve valve 4-cylinder engine, the car featured cantilever rear springs, a cone-type clutch with a 3-speed transmission. Electric control buttons on the steering column operated ignition, lights and horn.

U.S. patents 2,635,022 and 2,695,825

But today it takes the

PERFECT CIRCLE TYPE "98" CHROME OIL RING

to meet the exacting demands of modern high-compression engines

- Specifically designed for today's high-compression engines!
- Universal application...bottomless and conventional grooves...all depths
- Multiple tiny springs exert both side and radial pressure!
- Provides maximum oil drainage!



Best for new engines...essential for worn engines

PERFECT CIRCLE

PISTON RINGS

Preferred by more people than any other brand!

Perfect Circle Corporation, Hagerstown, Indiana
The Perfect Circle Co., Ltd., 888 Don Mills Road, Don Mills, Ontario

FACTS

about

NEW DEPARTURE BALL BEARINGS





New Departure split inner ring bearings are made in a range of sizes with and without inner ring puller grooves indicated in the exploded view above.

LOADS GET A LIFT with THIS BALL BEARING

Whether in helicopters or jet engines, New Departure ball bearings of split inner ring type provide very high load capacity. That's because the separable rings permit high race shoulders and a greater number of balls of large size.

These split inner ring *ball* bearings not only carry heavy thrust loads in either direction in addition to radial loads (with thrust predominant), but they have important application advantages.

Since both the inner rings and separator-ball assembly are removable from the outer ring as individual parts, the bearings are easily inspected or cleaned. In addition, installation is greatly facilitated.

Send for Folder TB listing sizes.

SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

MILESTONES IN POWER PROGRESS

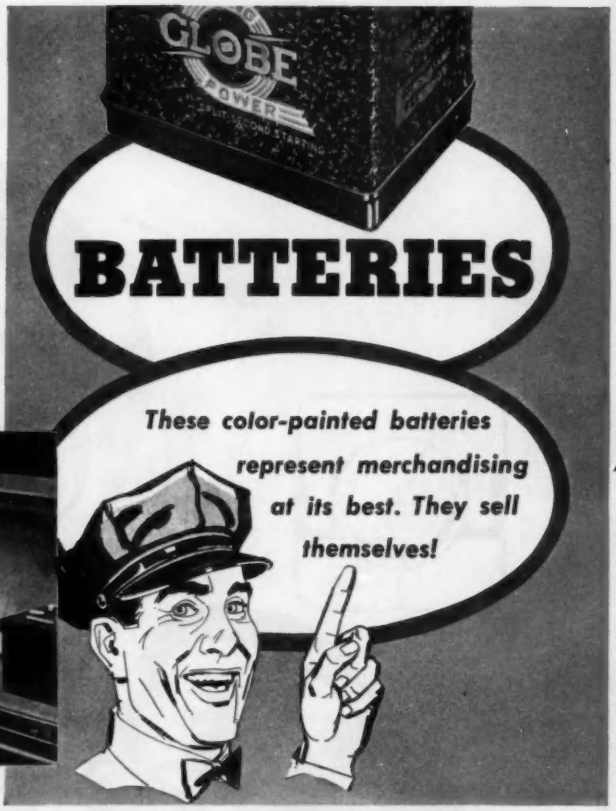
(NO. 3 IN A SERIES)

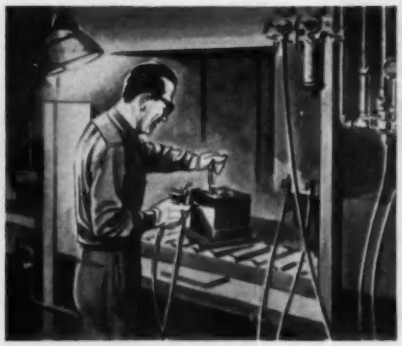


1907 — The first electric lights for cars

1955 — Globe introduces first mass-produced color-painted batteries

The first electric lights for cars touched off a welcome evolution towards safer, more enjoyable motoring. In the same vein, Globe pioneering not only improved the performance of batteries but also their appearance. The latest Globe *first* is mass-producing color-painted batteries for greater merchandisability and eye appeal.







In keeping with established quality control standards, Globe uses special paints for hand and spray painting operations. These are quick-drying to assure proper setting . . . long-lasting eye appeal.

Unmatched technical progress is only one of several Globe contributions to greater battery sales. Equally important, Globe's service includes modern battery merchandising — *through dramatic color*. Smart designs and vivid colors lift batteries from back-room stocks to prominent wall, counter and window displays that attract customers — build sales.

Another milestone in power — another *first* for Globe.

FOR FASTER, LOWER-COST DELIVERY!

Globe's sixteen plants are strategically located for fastest, lowest-cost shipments to all markets; thirteen (*) are producing creatively packaged dry-charged batteries.

*ATLANTA, GA., *DALLAS, TEXAS, *EMPORIA, KANSAS, *HOUSTON, TEXAS, *LOUISVILLE, KY., *MEDFORD, MASS., *MEMPHIS, TENN., *MILWAUKEE, WIS., *MINERAL RIDGE, OHIO, *PHILADELPHIA, PA., *REIDSVILLE, NO. CAROLINA, *SAN JOSE, CALIF., *HASTINGS-ON-HUDSON, N. Y., LOS ANGELES, CALIF., OREGON CITY, ORE., AJAX (ONTARIO) CANADA

SPINNING POWER

GLOBE-UNION

SPLIT-SECOND STARTING

GLOBE-UNION INC.

MILWAUKEE 1, WISCONSIN

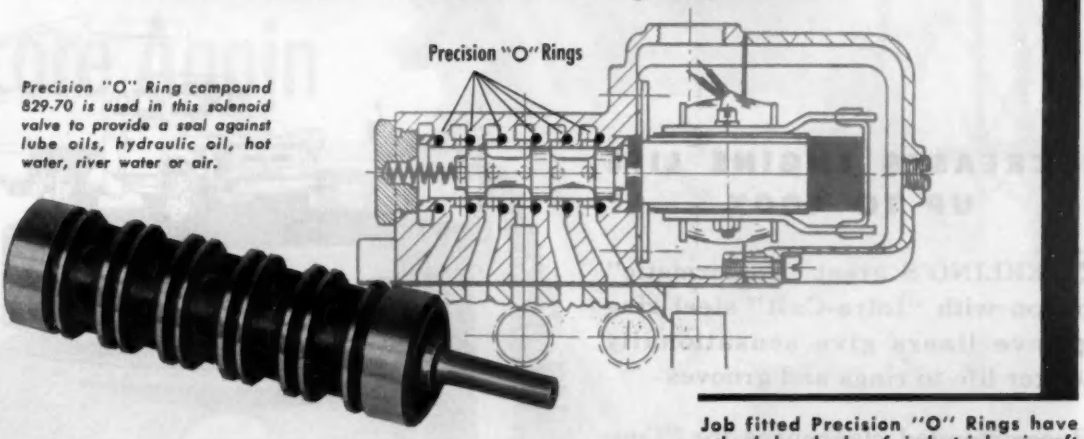
If it's Petroleum-powered there's a GLOBE-BUILT BATTERY right from the start!

SAE JOURNAL, April, 1957, Vol. 65, No. 5. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office, at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y.

COMPOUND 829-70

Versatile PRECISION "O" RING fills sealing requirement in dozens of industrial products

Precision "O" Ring compound 829-70 is used in this solenoid valve to provide a seal against lube oils, hydraulic oil, hot water, river water or air.

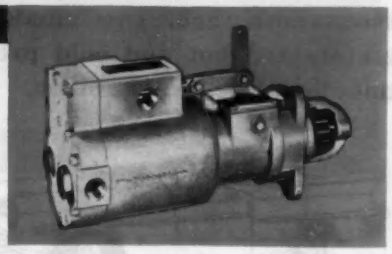


Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.

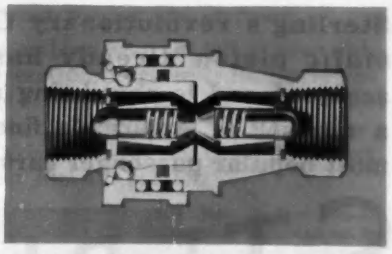
Uniformity of size, excellent surface quality, compatability with a wide range of fluids . . . Numatics, Inc. of Milford, Michigan, cite these as reasons why "O" rings made from Precision Compound 829-70 are being used in their solenoid valves. They are giving service through more than 30,000,000 valving actions.

Hundreds of Precision "O" Ring compounds are meeting the exacting requirements of industry. Modern pre-testing methods and engineering skill assure dependable, long life service. They are compression molded — rigidly inspected — meet all military and commercial specifications — the finest made! At Precision, you'll find "O" rings in sizes and compounds to meet your requirements.

What is your sealing problem? There is an expert — the Precision engineer — ready to help you in product design and "O" ring specifications. You can rely on him — and on Precision, the world's largest exclusive producer of "O" Rings.

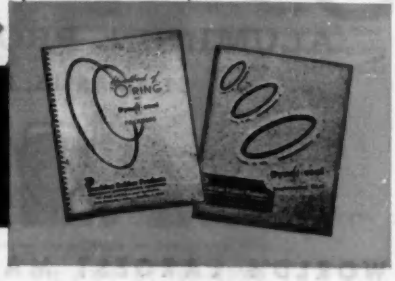


Precision "O" Rings were selected for this cranking motor after exhaustive tests for flexibility and sealing in arctic cold.



In this coupling, an "O" ring made from Precision Compound 829-70 seals against hydraulic fluids and pneumatics.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals



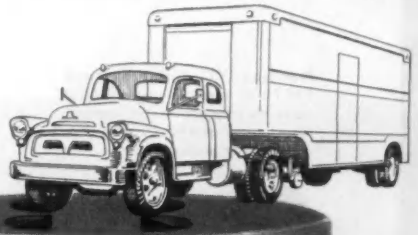
Precision Rubber Products Corporation · "O" Ring and Dyna-seal Specialists

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Canadian Plant at: Ste. Thérèse de Blainville, Québec

Rapidly becoming the

Standard of the Automotive Industry



INCREASES ENGINE LIFE UP TO 400%

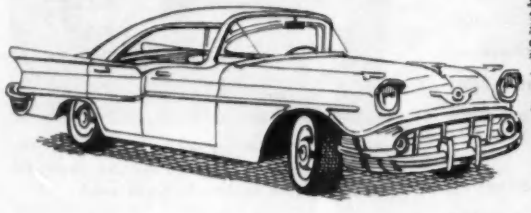
STERLING'S great "Conformatic" piston with "Intra-Cast" steel ring groove liners give sensationally longer life to rings and grooves—

Recommended clearances for "Conformatic" pistons are from 0 to ½ thousandth inch. This clearance is maintained hot and cold providing unbelievable bore stability.



STERLING'S CONFORMATIC PISTON WITH INTRA-CAST STEEL LINED GROOVES

prevents frictional horsepower loss, reduces oil consumption to an absolute minimum, and prolongs engine life up to 400%. *Intra-Cast* and *Conformatic* are registered trade names of STERLING Aluminum Products Inc.



Sterling's revolutionary *Conformatic* piston already has been accepted and is now being used in a number of America's finest and most popular passenger cars.

STERLING

ALUMINUM PRODUCTS INC.

ST. CHARLES, MISSOURI



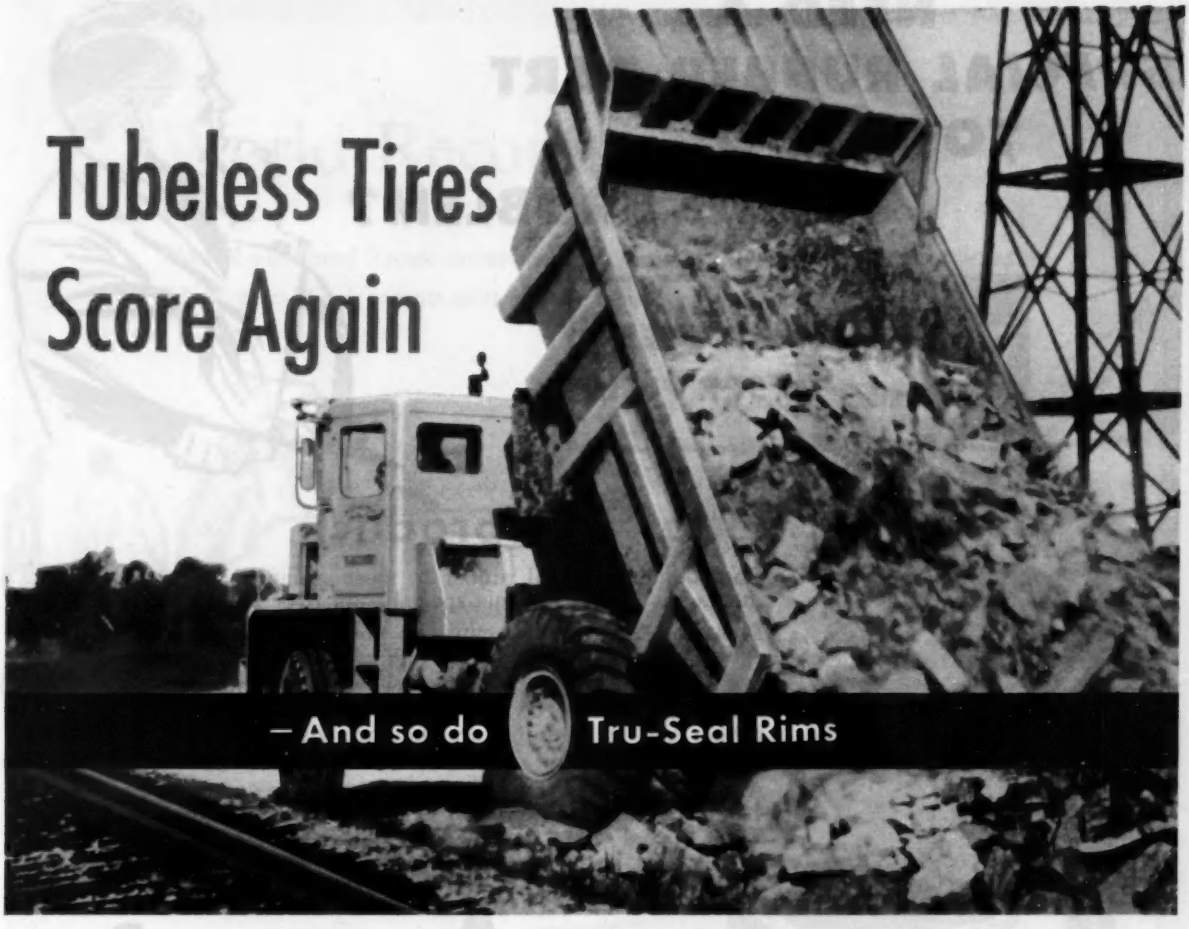
NEW MANUFACTURING FACILITIES FOR STERLING ALUMINUM

120 acres! Completely new automated plant at the confluence of the Missouri and Mississippi Rivers

SA-1

WORLD'S LARGEST MANUFACTURER OF ALUMINUM ALLOY PISTONS

Tubeless Tires Score Again



NOTHING's tougher on tires—or rims—than running over jagged rocks, as you may have good reason to know.

That tubeless tires can be used on such a job, and so effectively, is in large measure due to Goodyear's remarkable development—the Tru-Seal Rim. This is the rim that has been adopted as standard by the Tire and Rim Association for tubeless replacement of all conventional tire sizes 12:00 and larger.

Tru-Seal is the only practical, economical method yet devised to seal a multiple-piece rim. It's just one of the many advances resulting from Goodyear's matchless experience in building rims for every type of vehicle. When you specify Goodyear rims you get:

Unusual Strength: Thanks to an exclusive double-welding process, and added support at points of greatest stress, present-day Goodyear Rims are far stronger than previous rims.

Ease of Tire Mounting: No tube and flap troubles.

Special Tools: Goodyear alone provides both hydraulic and hand tools especially made for off-the-road equipment.

Bond-a-Coat Finish: This protective coating affords long-lasting resistance to rust and corrosion.

If you have a rim problem, why not talk it over with the G.R.E. (Goodyear Rim Engineer). He'll save you time and money by helping you select the type and size of rim best suited to your needs. Write him at Goodyear, Metal Products Division, Akron 16, Ohio, or contact your local Goodyear Rim Distributor.



New Tru-Seal Rims—for sizes 12.00 and up, including all earth-mover and grader sizes. This rim is similar to multiple-piece rims now in use—PLUS airtight Tru-Seal rubber ring which compresses into sealing groove when tire is mounted.

Buy and Specify **GOODYEAR**

Tru-Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND

NEED A *SPECIAL* RUBBER PART TO LICK A TOUGH PROBLEM?



PHOENIX **4-STEP SERVICE**

assures a better end product

Compounding special rubber to meet specific product requirements has been a Phoenix specialty for over 25 years.

Phoenix 4-Step Service can help you use natural or synthetic rubber in designing a better and often cheaper end product:

We will (1) analyze your problem, (2) assist in designing the rubber component, (3) compound and test the most suitable rubber and (4) manufacture the part with traditional Phoenix craftsmanship.

A Phoenix representative will gladly show you how Phoenix 4-Step Service can help you lick a tough product problem, as it did in case of the flexible coupling below.



THE CASE OF THE FLEXIBLE COUPLING

A flexible coupling component of an automobile window and seat assembly called for rubber bonded to nylon. The problem was to retain this bond under extreme torque running as high as 180°. Additionally, the rubber must not rupture, must be resilient and flexible to all temperatures and be resistant to oil. These characteristics must be retained for the life of the car.

Phoenix compounded a special synthetic rubber with all of the properties required and successfully bonded it to nylon. The component has surpassed all expectations, thanks to Phoenix skills with rubber.

Leading Manufacturers of Custom Molded Mechanical Rubber

PHOENIX

RUBBER PRODUCTS DIVISION

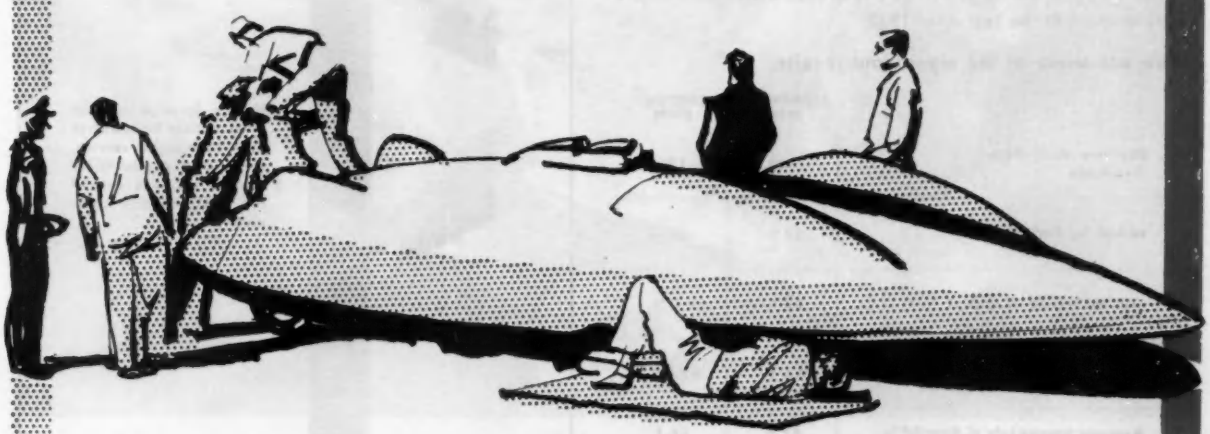
PHOENIX MANUFACTURING COMPANY

JOLIET, ILL. • FOUNDED 1862

Integrated Manufacturing Facilities: RUBBER PRODUCTS DIVISION, OIL AND GREASE SEAL DIVISION, FLANGE AND FORGING DIVISION, STEEL MILL DIVISION, HORSESHOE PRODUCTS DIVISION

World Records

World Land Speed Record drivers Segrave, Campbell, Eyston and Cobb all relied on E.N.V. gears. Their records of success are tributes to the quality of E.N.V. products.



and World Markets

E.N.V. are manufacturers of all classes of bevel and hypoid gearing, helical and spur gearing, final drives and transmission units. They invite enquiries from companies in the United States of America wishing to develop the manufacture and sale of engineering products in Britain, Europe and the British Commonwealth.

Co-operation with E.N.V. brings the manufacturing resources of modern equipment comprised in two factories covering over a quarter of a million square feet, a capable and experienced labor force and the technical and general experience to gain access to new and expanding markets in many lands.

ENV

E.N.V. ENGINEERING COMPANY LTD. HYTHE ROAD, WILLESDEN, LONDON, N.W.10, ENGLAND

Test Shows

Armco ALUMINIZED STEEL Doubles Average Muffler Life

Actual road tests from 1948 to 1955 showed that automobile mufflers made of Armco ALUMINIZED STEEL® Type 1 outlast carbon steel mufflers *at least two to one* on the average.

The test was conducted by replacing failed original carbon steel mufflers on privately owned automobiles with mufflers made wholly or partly of Armco ALUMINIZED STEEL. No mufflers were entered in the test after 1952.

Here are some of the significant results:

	ALUMINIZED STEEL	CARBON STEEL
Mufflers With Data Available	150	126
Failed by End of Test	37%	100%
Still in Service at End of Test	63%	0.0%
Failed Within First 24 Months of Service	4.6%	42.0%
Average Service Life of First 37% to Fail	42.6 Months	18.1 Months
Average Service Life of Failed Mufflers	42.6 Months	29.3 Months
Average Service Life Expectancy of ALL Mufflers, Including Those Still in Service at End of Test	58.0 Months	29.3 Months
Shell Failures	9%	85%

OTHER FINDINGS

Of the 56 ALUMINIZED STEEL mufflers that failed during the test, 44 were returned for examination. On mufflers with some carbon steel parts, more than 70 per cent of the failures were due solely to rusting out of the carbon steel; the ALUMINIZED STEEL parts were still serviceable.

These test results indicate that Armco ALUMINIZED STEEL in any muffler part increases not only the life of that part, but also the average life expectancy of the muffler as a whole. This was especially true of the shell, the most vulnerable component.

Since dual exhaust systems have greatly increased replacement costs, new car owners are especially conscious of muffler life. For a powerful sales advantage, consider mufflers made of Armco ALUMINIZED STEEL for *your* cars. For complete information on this special steel, write us at the address below.



Here's how a carbon steel muffler looked after only 18 months' service. Heat and products of combustion have caused the shell to fail completely.

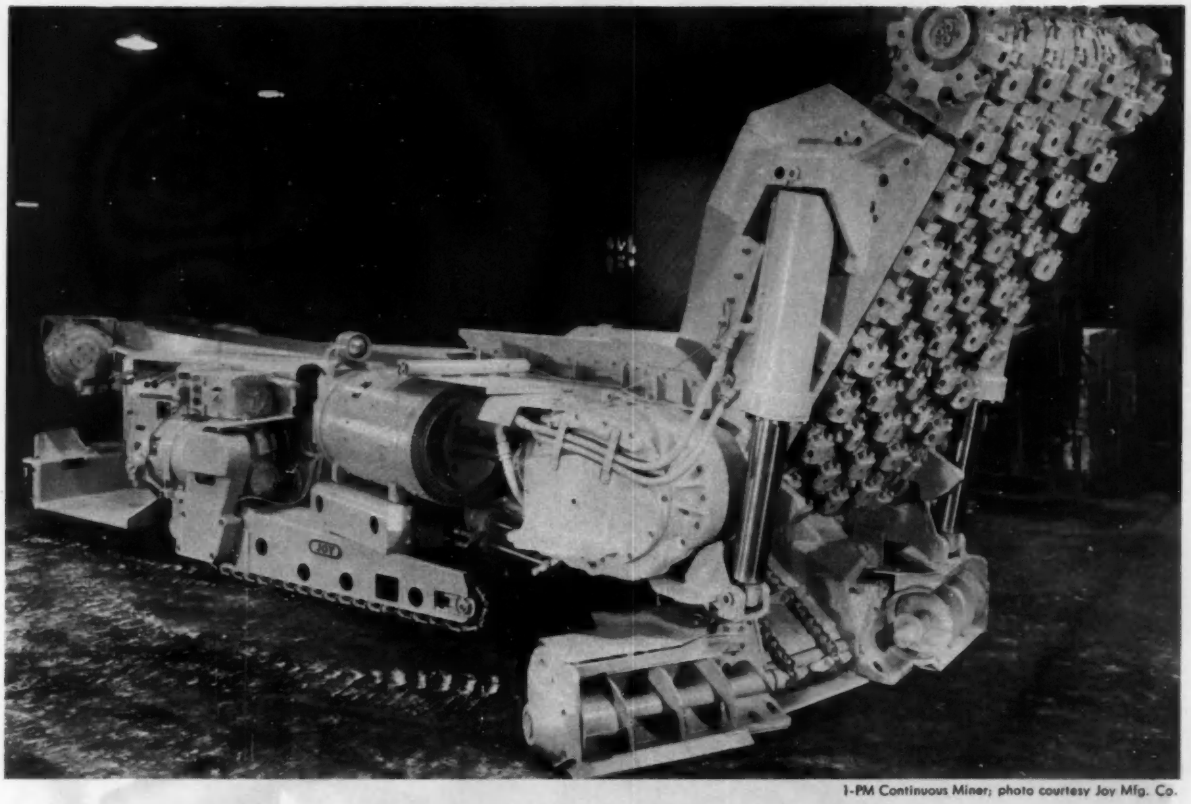


This ALUMINIZED STEEL muffler has already given 55 months' service. The shell is unbroken. The special aluminum coating is still protecting the base metal.

ARMCO STEEL CORPORATION

1077 Curtis Street, Middletown, Ohio

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation



1-PM Continuous Miner; photo courtesy Joy Mfg. Co.

What a brake for industry!

(Solution to tough industrial braking problems)

IF you're faced with a tough industrial braking operation—one that can't be solved by a conventional, off-the-shelf brake—*then cast a critical engineering eye over the performance advantages offered by the Goodyear Industrial Disc Brake.* (You'll find them listed below.)

Pictured above is a good example of its rugged durability: operating under extreme conditions on this continuous miner — where conventional brakes cannot meet rigid specifications for space, capacity and dependability.

Born of aeronautical pioneering, developed to stop the world's fastest and largest jet aircraft, the Industrial Disc Brake can be custom designed to solve the most difficult assignments — *proved* on turbo-prop engines, transmission brakes, machine tools, material handling trucks, helicopter rotors, logging equipment, dynamometers and the like.

For complete information and an on-the-job analysis of your special problem, write: Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

The Goodyear Industrial Disc Brake offers these many advantages:

Smooth Action—non-self-energizing, it produces equal torque in either direction proportional to the force applied. **Faster Cooling** – has higher kinetic energy absorption capacity than any other industrial brake of comparable size. **Flexibility** – design principle permits almost any combination of torque and energy capacities. **Versatility** – can be operated hydraulically, mechanically, pneumatically or can be spring-set, solenoid-released. **Automatic Adjusting** – hydraulic- and air-actuated units have automatic compensation for lining wear. **Economical** – saves on equipment "down time" due to quick, easy lining replacement.

GOODYEAR
AVIATION
PRODUCTS



▶ **Hydrapower** is "power to accomplish" . . . "power to earn"! In short, Hydrapower is *profit* power, for vehicles of many different types.

Hydrapower Models HPS-52 and HPS-70, pictured above, are setting new standards of steering ease, safety and economy for trucks, farm machinery and industrial equipment.

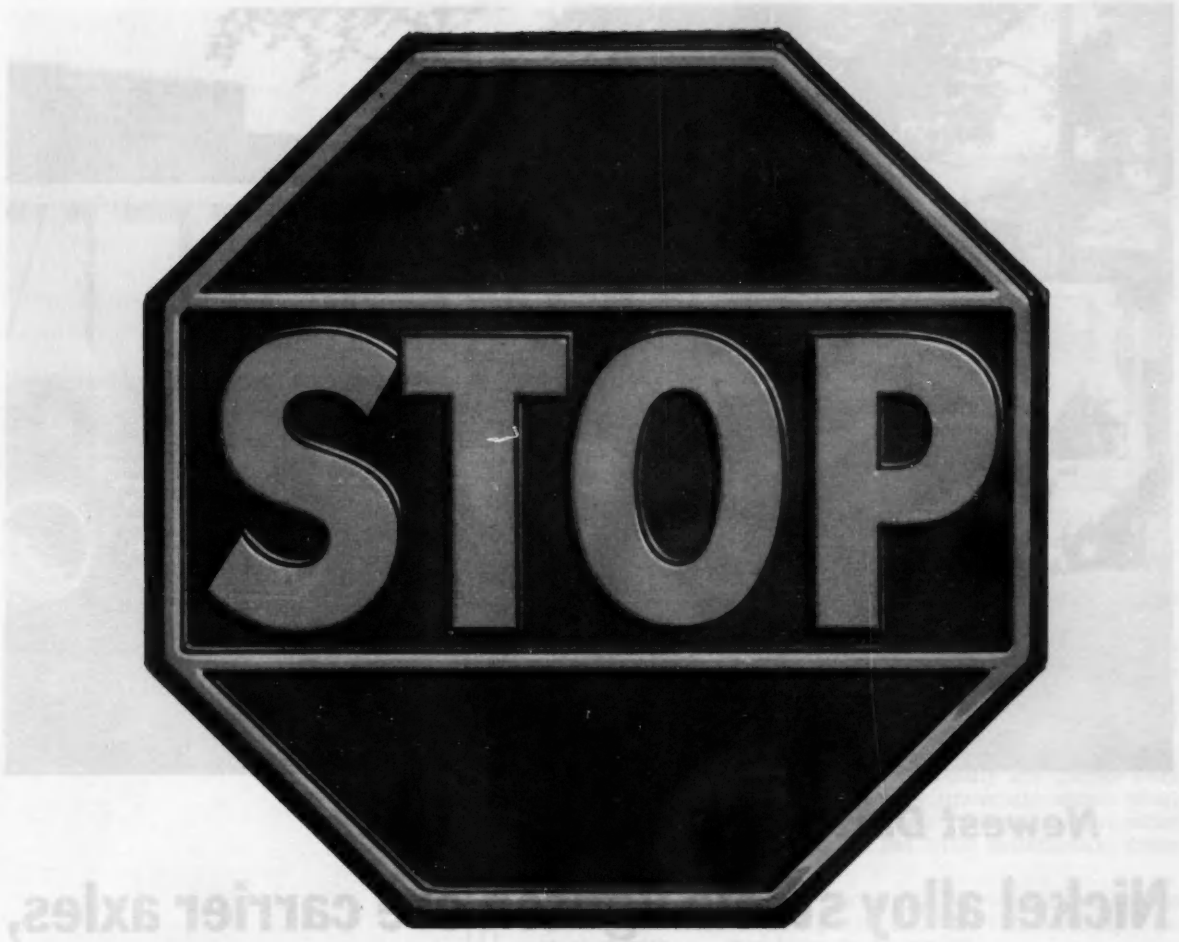
You may be sure there's a Hydrapower unit to do the same for *your* product . . . because Ross makes *all three* types of hydraulic power steering—semi-integral, integral and linkage.

Ross invites discussion of *any* steering problem—power or manual.

ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA
Gemmer Division • Detroit

Ross

HYDRAPOWER





The drafting stage—not later—is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

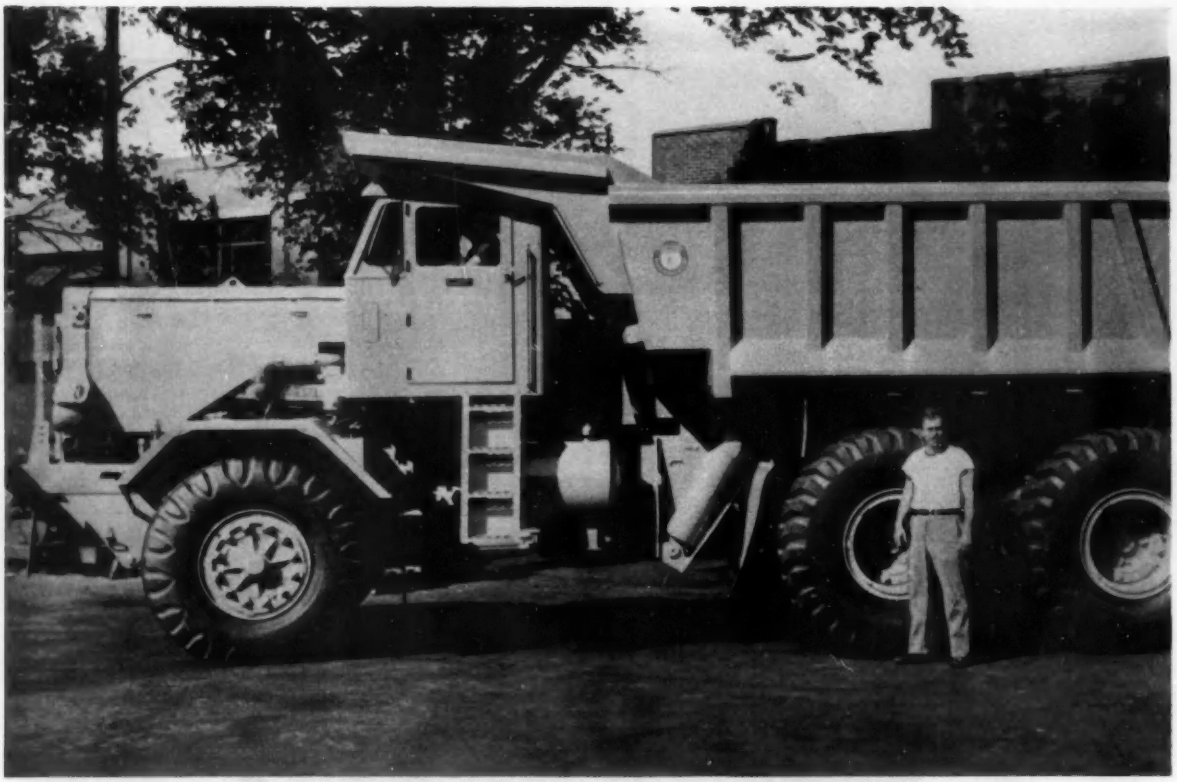
Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

Why "do it yourself?" Call the nearest National Oil Seal Engineer now.

NATIONAL SEAL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio and Redwood City, California



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Newest Dart 55-ton...

Nickel alloy steels lighten ore carrier axles, absorb terrific loads and impacts

"In 22 years," Dart metallurgists say, "we've found no stronger, tougher axle steels"

This is a real bear cat . . . 55 tons, 25 cubic yards, 400 horsepower.

It's the latest of a long line of heavy-duty, high-capacity Dart trucks.

Like their first model built 22 years ago, it is designed for maximum load capacity and minimum tare weight. And like their first (many of which are *still* in service) its axle shafts are forged of 4340 nickel-chromium-molybdenum steel. They are heat-treated to a hardness of 400/440 Brinell, equivalent to tensile strengths ranging above 200,000 p.s.i.

The housings are alloy steel castings, of approximately Type 4335 composition, heat-treated to provide a minimum tensile strength of 100,000 and yield strength of 85,000 p.s.i.

Dart has never found another steel to equal the 4300 type for heavy-duty axles . . . and they've tried many. Here's what it gives them:

1. Dependable high strength that allows safe designing for low weight.

2. Toughness to resist bone-shaking impact under heavy loads and low operating temperatures.

3. Good machinability at high hardness.

4. Excellent hardenability.

5. Ready weldability along with high strength in cast housings.



Light, strong, easy-to-fabricate. This is the axle assembly for the Dart ore carrier. Housing contains a triple reduction power transmission; wheels, a double reduction carrier and single reduction planetary. To increase the strength/weight ratio and obtain top-notch casting and machining properties, Dart Truck Company, Kansas City, Mo. makes both shaft and housing of medium carbon nickel-chromium-molybdenum steels.

* * *

Nickel alloy steels are used for dependable trouble-free performance in the most demanding applications. Do you have such a problem in your equipment? Send us the details, we may be able to help you . . . write today.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

For the Sake of Argument

Too Busy . . .

By Norman G. Shidle

These days, everybody is too busy. We're sure, because a corps of personal Worry Gremlins keeps needling each of us about what we've left undone. Whatever it is we think most worth while doing, our Worry Gremlins tell us there isn't time for.

The Worry Gremlins reiterate so boldly the things *they* say we should be doing, we become uncertain about what *we* think we should be doing. They shriek so about what we have left undone, that we get little satisfaction from what we have done.

One engineer recently eluded his WG's long enough to ask himself some cogent questions. "So I'm too busy," he started with. . . . Too busy doing what?

"Too busy doing whatever brings itself to my attention to leave room for what I wish to put my attention on?

"Too busy answering mail and telephones and visitors concerned with what *they* feel is most important to leave time for calls and letters and people needed to get on with what *I know* is most important?

"Too busy trying to decide what to do first to get time to get started doing it?

"Too busy debating courses of action to get time to take any of them?"

This engineer found, of course, that his questions were easier to ask than to answer. But he garnered an immediate, surprised satisfaction in the vacation from his Worry Gremlins. He found delight, for a change, in working on problems posed by himself.

Then he got to wondering. "Where did my Worry Gremlins go? I've been battling them for years. This is the first interlude in months of my arguing with them.

"Could it be," he soliloquized, "that they were just figments of my imagination . . . that they vanished as soon as my mind left them? Maybe they live only as I think of them. Perhaps I've been keeping them alive by fighting them.

"Maybe they are most afraid 'of the destructive calm of one who knows they are nothing.' . . . Maybe I've gotten too busy for Worry Gremlins!"



For Important Savings in Your Engine Costs Use EATON Aluminized Inlet Valves

Modern high-output engines require inlet valves with superior scale resistance. Heat resistant alloys have solved this problem, but at a cost premium. Valves made of low cost materials and aluminized by the Eaton aluminizing process have corrosion resistant qualities equal to, or better than, valves made of higher priced alloy materials.

Let our engineers help you apply the cost-saving benefits of Eaton aluminized inlet valves to your engines.



Plain carbon steel valve with aluminized face after exaggerated test of 16 hours in air atmosphere at 2000°F. Note the gross oxidation of the non-aluminized stem area and the excellent condition of the aluminized seat-face and margin.

EATON

VALVE DIVISION
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Forgings • Heater-Defroster Units • Automotive Air Conditioning Fastening Devices • Cold Drawn Steel • Stampings • Gears • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

SAE Journal

Norman G. Shidle
Editor

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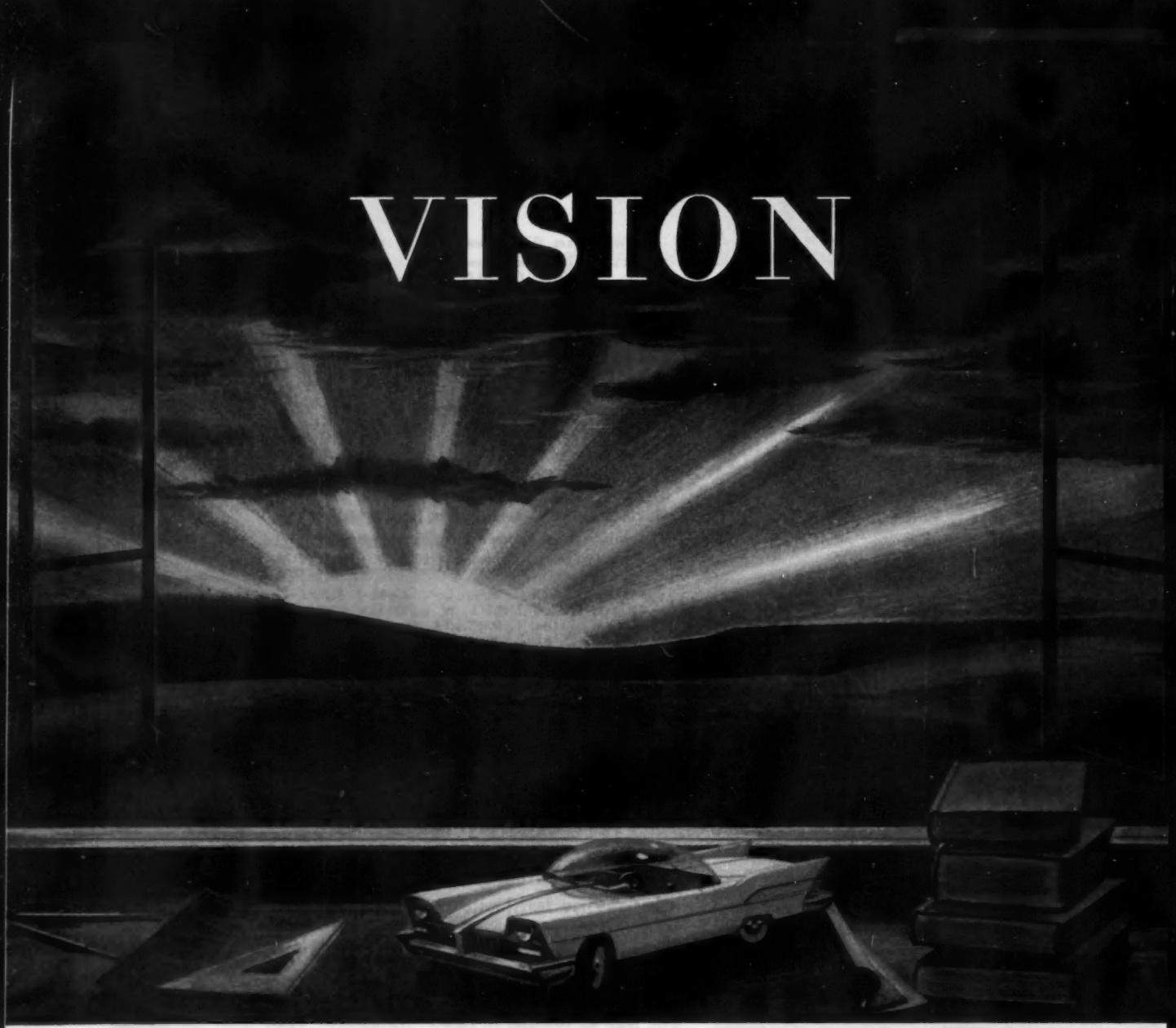
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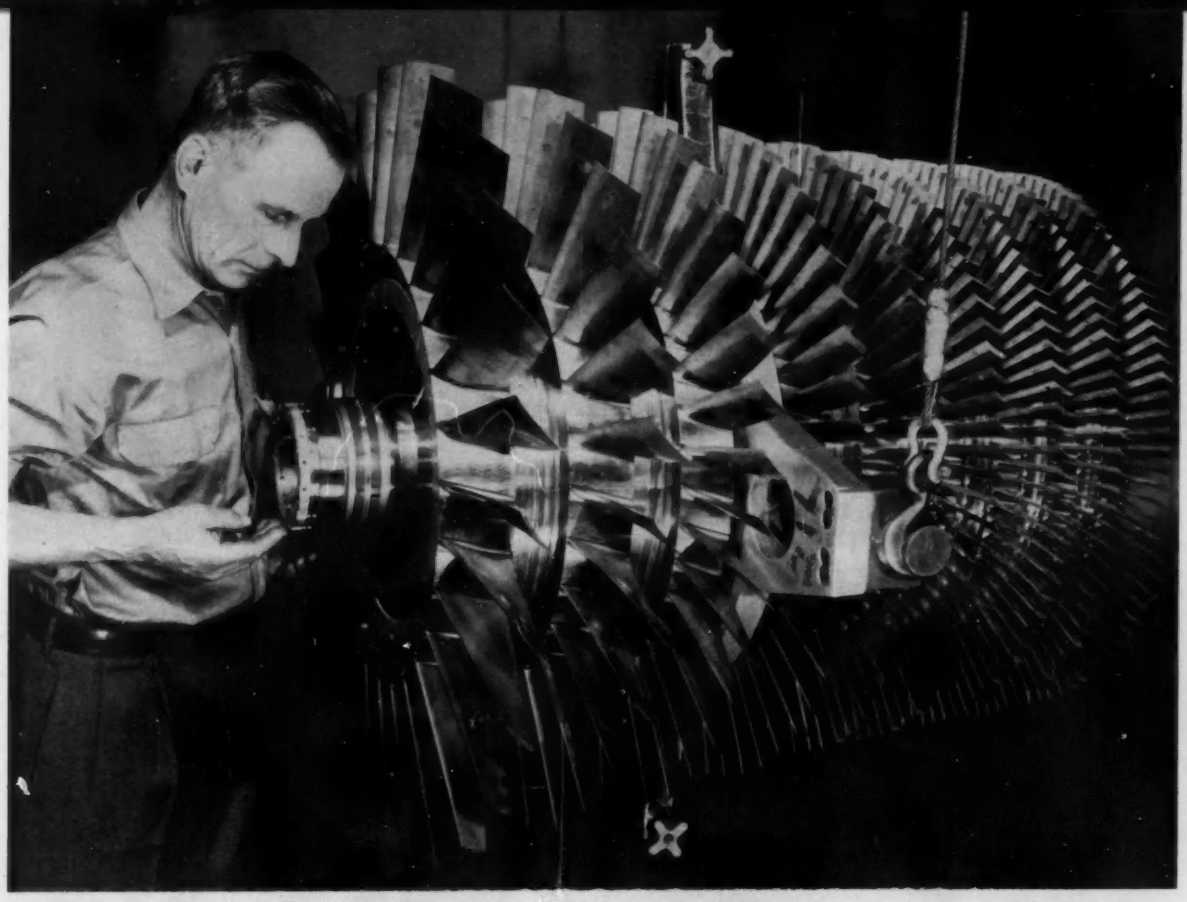


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BLADING OF THIS J57 LOW-PRESSURE COMPRESSOR is made of titanium alloy. Titanium has the advantages of being more corrosion resistant and lighter than steel. Compressor blades made from titanium operate at lower vibratory stresses, and they have good fatigue strength. Result is better fatigue life.

P&WA Makes J57 Compressor of Titanium

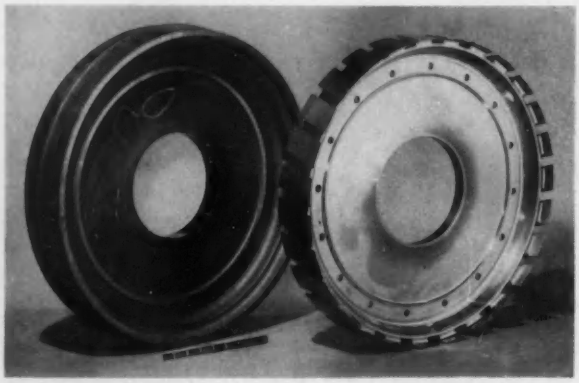
Based on paper by **Winston H. Sharp,**
engineering metallurgist, Pratt & Whitney Aircraft Division, United Aircraft Corp.

PRINCIPALLY to save weight, some models of the J57 turbojet engine include many alloy titanium parts, particularly in the low pressure compressor.

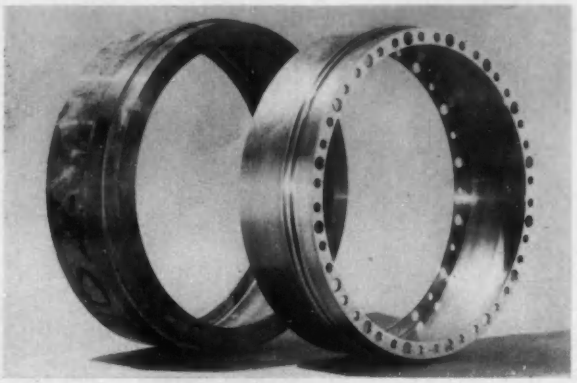
Numerous engines with titanium rotor parts of the 150A, 140A, and C-130AM titanium alloys have been produced, and considerable flight time has been accumulated. Recently we have gone into production with the newer 6Al-4V (6% aluminum, 4% vanadium) alloy. All of our experience indicates that this alloy represents the best balance achieved in an alpha-beta titanium alloy to date. The 6% aluminum gives it good elevated temperature strength up to 800 F and imparts oxidation resistance in the hot processing range. The 4% vanadium — a beta forming element — provides strength and added insurance against instability under a stress at elevated temperature.

A very significant advantage of the 6Al-4V alloy is its reduced density due to the relatively low densities of aluminum and vanadium. It is about 5% lighter than the Ti-150A and Ti-140A alloys and 2% lighter than C-130AM. Thus, for a given volume requirement, the 6Al-4V alloy is also the least costly. Currently we are specifying the 6Al-4V alloy for blades, discs, and disc spacers.

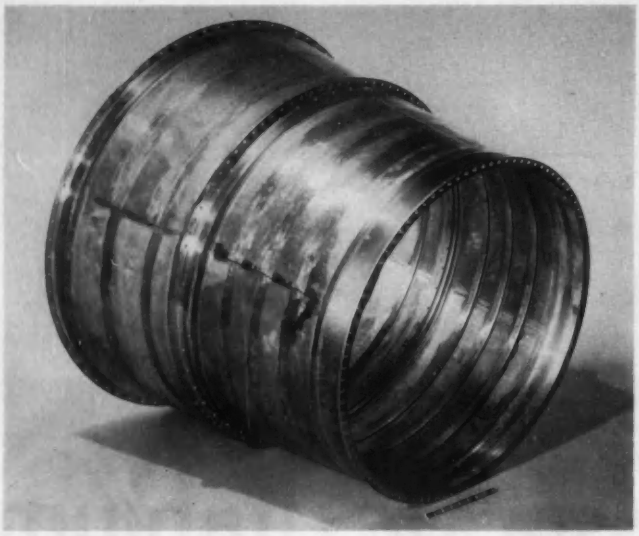
For a part subject to only moderate stress levels, the most attractive alloy (aside from commercially pure titanium, which is being specified where form-



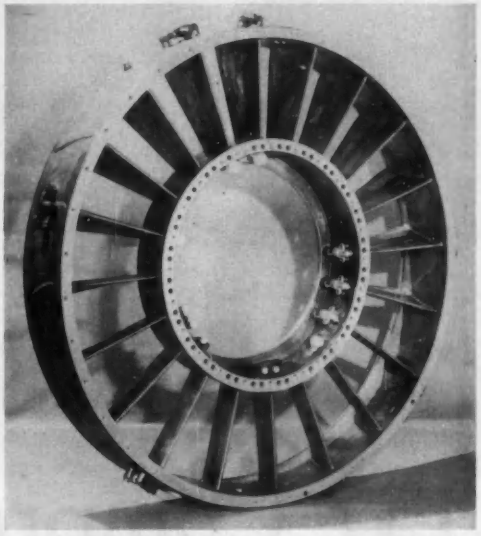
J57 FIRST STAGE titanium alloy compressor disc shown as-machined on the right weighs 26 lb, which is 36% of weight of its forging shown on the left. (Same disc in steel weighs 44.2 lb, which is 35% of weight of its forging.) It's possible that even better utilization may be achieved.



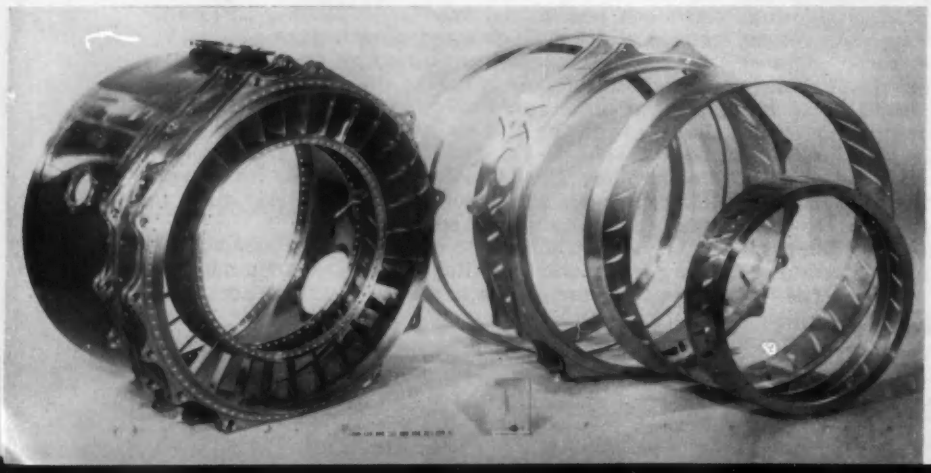
COMPRESSOR SPACER is machined from rolled ring of contoured cross-section. Finished spacer utilizes only 11% of material of original forging because of thinness of section. Ways are being sought to machine spacer from more closely contoured forging.



COMPRESSOR CASE SKIN is supported by rings machined from extrusions and flash butt welded. Both skin and supporting rings are of titanium. Rings were formerly machined from either commercially pure titanium or A-110-AT alloy bar stock, but currently extrusion of the alloy presents problems and only the pure titanium is being used.



ALLOY INLET CASE utilizes sheet metal plus flash butt welded extruded shapes. Extrusions are cheaper than inlet cases formerly machined from rectangular section. Because of the considerable amount of sheet metal used utilization efficiency is high.



CASE for intermediate compressor made of A-110-AT titanium alloy is most complex weldment in the J57. Plans are to replace outer rolled ring with flash butt welded contour forging, and forged inner shroud and forged vane with hot formed sheet.

ing and welding are required) for welded stationary applications is A-110-AT alloy (5% aluminum, 2.5% tin). This alloy is specified for compressor cases of the J57 engine. High yield strength coupled with good weldability are the characteristics which have determined selection of this alloy.

Much progress has been made recently in the utilization of titanium for our engine parts. Although we have been producing engines with titanium rotors less than two years, we have improved the utilization of titanium for these parts to the point where it is the same as for the steel counterparts. We have "reached the first plateau," and we are now at the point where we will have to resort to refinements and new techniques in forging and rolling practices. Consideration is even being given to reduction of metal loss that occurs in cutting billet and bar into cut blanks.

To permit interchangeability to titanium and steel components, the current titanium compressor rotor in advanced models of the J57 is a duplicate of the steel compressor.

Refinements have been made in the forging of the first stage compressor disc of the J57 engine such that the cut weight for the compressor disc forging has been reduced from about 120 to 75 lb. This represents a percentage reduction of 35–40%. The weight of the finish machined disc is 26 lb; thus, the utilization ratio (finished weight divided by input weight) has gone from an original value of 0.21 to the present value of 0.36. Figures for the steel disc are as follows: input weight, 126 lb; finished weight, 44.2 lb—which gives a utilization ratio of 0.35. Thus, it is evident that in making the recent advances in forging of titanium compressor discs we are competing with steel on a utilization basis.

The utilization ratio for titanium compressor blading runs between 0.25 and 0.50, depending upon the manufacturing practice. It must be noted that high utilization ratios have been obtained both by precision forging and by the rolling method. Generally speaking, up to now titanium blades have been made by the same methods as have been employed for steel blading. Application of titanium to blading, however, has stimulated much development work directed toward improved utilization. The current price of titanium is a very real deterrent to poor utilization of metal, and we can expect to see continuing progress in this area.

The situation with respect to compressor disc spacers is similar to the two previous rotor parts cited in that the utilization ratio for titanium at 0.11 is the same as for steel. Compressor spacers are machined from rolled (expanded) rings of contoured cross section. The configuration of the finished spacer with its thin sections does not make for a high utilization ratio. Our approach is to bring the contour in closer to the finished part in order to obtain a higher ratio.

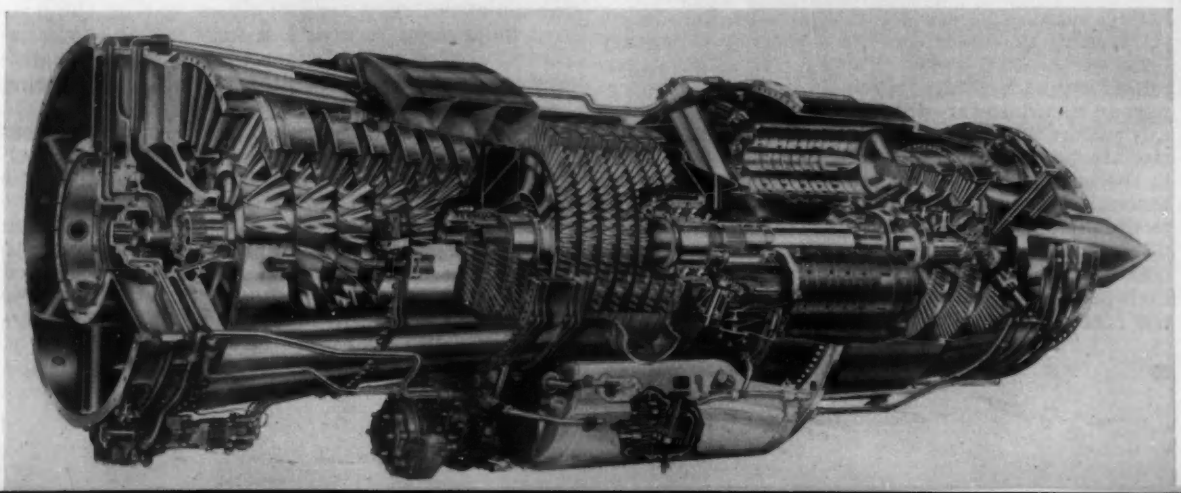
In weldments such as the low compressor case, which has been produced in both the commercially pure grade and A-110-AT, utilization is relatively high because much of the weight is in the sheet metal skin. The rings which support the skin are machined from flash butt welded rings. In making the welded rings of extruded sections instead of from rectangular bars, we have recently made a notable gain in utilization. Although the commercially pure grade is being extruded into such shapes, extrusion of A-110-AT alloy presents problems. It is probable that some time will elapse before A-110-AT extrusions are available for use in our welded structures.

The inlet case is another example of relatively high utilization, due to the predominance of sheet metal in the structure. In this more complex weldment we have recently gone to flash butt welded extruded shapes instead of the expensive rectangular section.

The intermediate compressor case made of A-110-AT titanium alloy is the most complex weldment we have tackled, and much development effort is going into the reduction of metal in the various rolled rings and forged components. We have every expectation that a high utilization ratio will be obtained by replacing the outer rolled ring with flash butt welded contour forgings and by replacing the forged inner shroud and forged vane by sheet metal which will be hot formed.

(Paper, "Alloy Titanium in the J57 Turbojet Engine," on which this abridgment is based, is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

TITANIUM-LOADED J57 is a twin-spool axial-flow turbojet engine made also in non-titanium versions. The J57 powered the Navy's Chance Vought F8U Crusader to a new American speed record at 1015 mph. It also powered the eight-engined B-52 intercontinental bombers on their recent record-breaking round-the-world flight. Other planes using the J57 are the Air Force's North American F-100 and the McDonnell F-101 fighters, the Convair F-102 interceptor, the Boeing KC-135 jet tanker transport, and the Navy's Douglas A3D and F4D.



GM's Fuel-Injection System

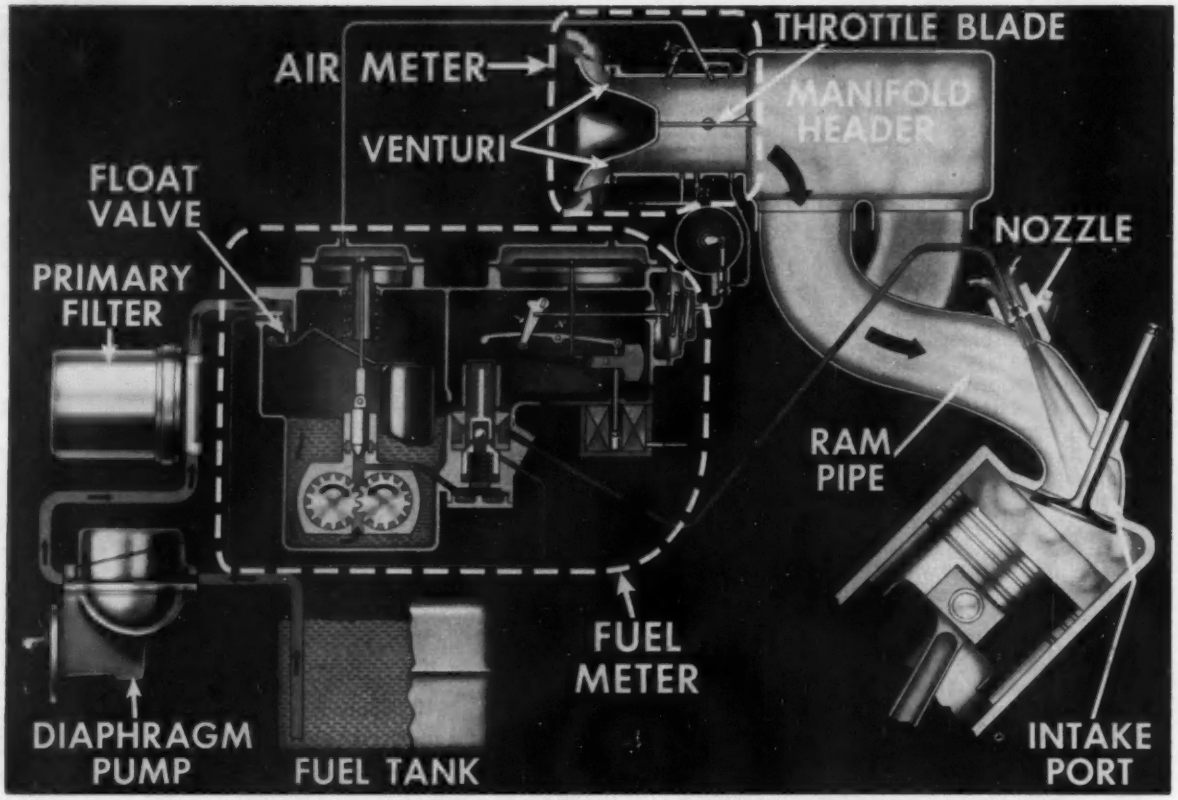


Fig. 1—GM fuel-injection system uses continuous-flow injection into intake ports.

THE GM fuel-injection system (Fig. 1) uses continuous-flow injection into the intake ports, with open orifice nozzles directing the fuel toward the intake valves. Control is based on mass flow metering, in which venturi throat depression is related mechanically to fuel pressure.

The following description illustrates how this was achieved.

Description

Fuel supplied by a conventional 6-psi diaphragm pump (Fig. 1) passes through a 10-micron primary filter to the fuel meter (Fig. 2). The fuel is admitted through a float valve—similar to its counterpart in a carburetor—into the float chamber where any vapors which have formed due to temperature rise are vented. A small gear pump (Fig. 3) located in the bottom of the float chamber delivers the fuel through a second inlet filter (Fig. 4) and a fuel valve to the metering cavity (Fig. 2). The fuel valve contains an antipercolation ball check to keep the fuel between the valve and the pump at a sufficiently high pressure to eliminate vapor pockets. Some of the fuel delivered to the metering cavity flows directly to the eight continuous spray nozzles; the remainder of the fuel flows through the spill ports back to the float chamber. The amount of fuel spill is regulated by the spill plunger.

Air enters the air meter (Fig. 5) through the annular venturi section and flows past the throttle blade to the manifold header and then to the individual intake ports. The air velocity through the venturi causes a depression signal related to the mass airflow. This venturi signal acts on the control diaphragm to create a force which is transmitted to the spill plunger by means of the diaphragm link and control arm, the latter being pivoted on the ratio lever.

An increase in airflow through the venturi causes a relative increase in venturi signal that, acting on the control diaphragm, results in an increase in the force acting on the top of the spill plunger. The spill plunger then moves to a new balanced position to obtain a fuel pressure increase proportional to the venturi signal increase. Since the increased fuel pressure results in a fuel flow proportional to the increase in airflow indicated by the venturi sig-

—Here's How It Works

Based on paper by **John Dolza, E. A. Kehoe and Donald Stoltman, Zora Arkus-Duntov**
Engineering Staff, GMC Rochester Products Division, GMC Chevrolet Division, GMC

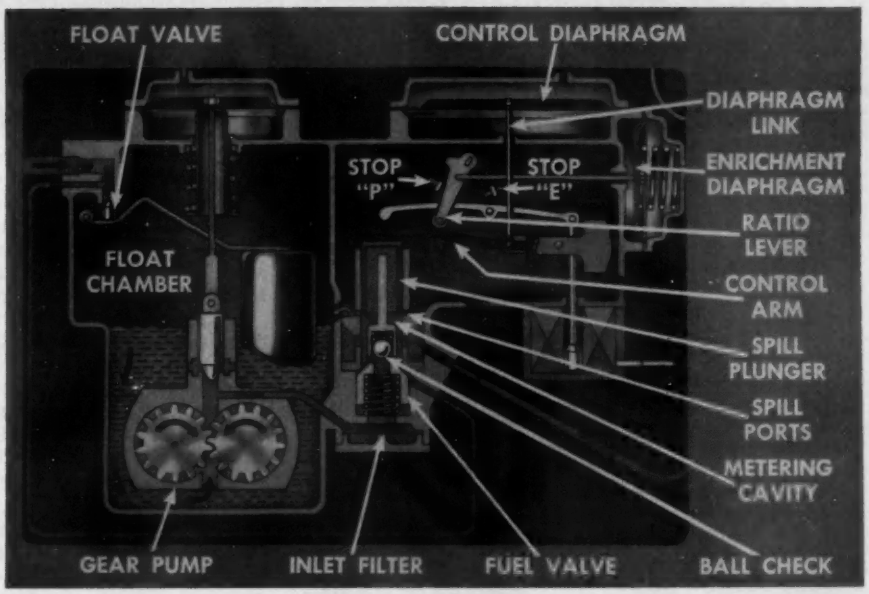


Fig. 2—Fuel meter.

nal, a constant air-fuel ratio will be maintained as long as the linkage ratio is not changed.

How Air-Fuel Ratio Is Changed

The air-fuel ratio can be varied by changing the linkage leverage between the control diaphragm and the spill plunger. This is accomplished by shifting the pivot point on the control arm. When the "ratio lever" rests against stop "P" (power), the air-fuel ratio obtained is for wide-open-throttle operation (Fig. 6); when resting against stop "E" (economy), part-throttle fuel requirements are fulfilled. For automatic operation, the ratio lever is controlled by the spring-loaded enrichment diaphragm which is subjected to manifold vacuum; at light load (high vacuum) the lever is held at position "E," at full load (low vacuum) at position "P."

The stops are set to obtain a best-economy air-fuel ratio (about 15.5/1) at part throttle and a maximum power air-fuel ratio (about 12.5/1) at wide-open throttle. The enrichment diaphragm spring is set to hold the ratio lever in the economy position



Fig. 3—High-pressure pump.

Pump is flange-mounted to side of bowl with 1/64-in. Buna N rubber-on-nylon gasket. Delivery to fuel meter is routed through this flange. Second delivery path is opened to prevent fuel delivery to nozzles when car is coasting. Pump runs at one-half engine speed. At any engine operating speed, fuel delivery averages twice wide-open-throttle requirement. This allows compensation for normal wear and is decided benefit to instantaneous acceleration. Power is taken from ignition distributor drive shaft through shielded flexible shaft.



Fig. 4—Second filter with sleeve, and plunger.

This filter is placed between gear pump and spill plunger to trap any rare particles which might plug nozzle. Present design calls for 3/16×1-in. diameter capsule of compressed Monel wire, which passes no particle over 0.004 in.

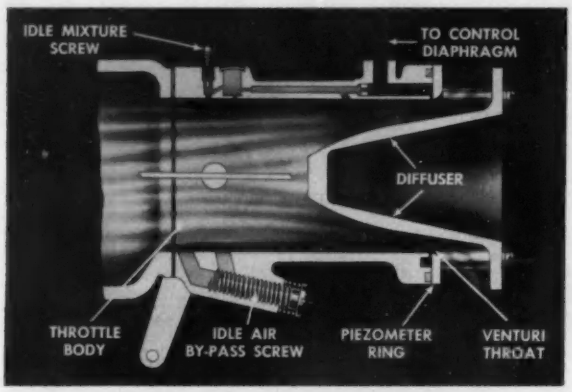


Fig. 5—Air meter at wide-open throttle.

Unique radial-entry annular venturi now used (as shown above) proved better in many respects than conventional axial-flow venturi originally used. Length required for just original venturi was as great as now required by complete air meter. At 24 lb per min, loss across venturi is only 2 in. of H_2O, while signal or velocity pressure is 30 in. of H_2O.

Inlet to venturi throat is so arranged that no component of air velocity can act upon piezometer slot. Vertical location and concentricity of diffuser fortunately are not too critical, therefore controlling dimensions have 0.002–0.004 in. total tolerance. An unexpected critical part proved to be blending of inlet radius on piezometer ring. It appears that streamline variation in vicinity of slot cannot be tolerated if signal is to be held constant.

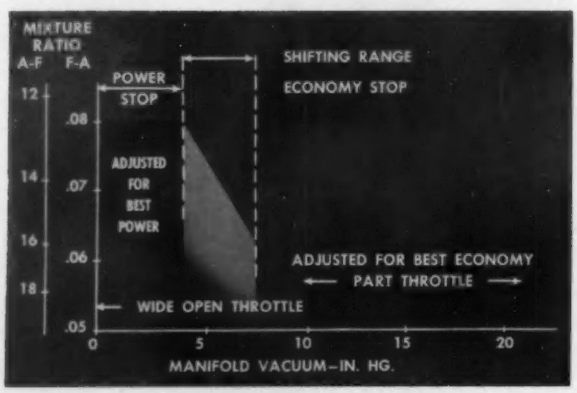


Fig. 6—Operating mixture ratios.

above about seven inches mercury vacuum.

The nozzle (Fig. 7) has an accurately calibrated open fuel orifice somewhat less than 1/64 in. in diameter. The nozzles are mounted, at the entrance of each intake port (Fig. 8), in plastic nozzle holders. Just below the fuel orifice, there is a small air chamber which receives filtered air through four 0.100-in. diameter air holes from the air cleaner. This air supply assures that the nozzle discharge is at all times near atmospheric pressure regardless of manifold vacuum fluctuations, and consequently the amount of fuel injected depends solely on the metering system pressure. In line with the fuel orifice across the air chamber is the opening to the intake port. This is a 0.040-in. diameter air orifice. It should be noted that, under all manifold vacuum conditions, the atomization of fuel is enhanced by the mixing of air and fuel through this 0.040 orifice. The air volume passing through the air orifice represents about one-fourth of the air used at closed throttle for idling.

The tubular skirt below the air orifice is cooled by evaporation of the fuel, which in turn cools the fuel line by conduction, thus preventing metering disturbances caused by fuel vapor bubbles. In fact, the fuel at the nozzle and in most of the line is at a lower temperature than when it entered the system from the diaphragm pump.

By using this scheme of refrigerating the fuel by means of its latent heat, this open orifice type of nozzle becomes suitable for handling high-vapor-pressure fuel even under summer conditions. The nozzle operating temperature range of this nozzle, due to its location and insulation, is much lower than that of nozzles used in other fuel-injection systems (Fig. 9). This lower temperature range greatly reduces vapor problems.

The fuel orifice size was selected to give a minimum pressure at idle and cranking of about eight inches fuel head and a maximum pressure of the order of 200 psi at engine top speed and wide-open throttle. Under normal driving conditions, the pump pressure seldom exceeds 20 psi (Fig. 10). These moderate pressures can be achieved with a plain gear pump.

The fuel pressure at idle and when starting has been found sufficiently high to prevent adverse distribution effects caused by normal engine attitude changes.

Idle Operation

During idle operation the throttle is closed and about one-fourth of the air requirement is supplied through the individual nozzle air chambers. The rest is provided through a passage around the throttle blade and is regulated by the idle air bypass screw (Fig. 11) within the throttle body. The correct idle mixture is set by means of the idle mixture screw. This screw controls the amount of venturi signal boost caused by bleeding in manifold vacuum from the idle orifice.

To increase the range of idle adjustment for all atmospheric conditions and all altitudes, and particularly at the height of Pike's Peak, which is so dear to Chevrolet's heart, a fuel-rate reduction device was incorporated. Fig. 12 illustrates the method by which a pressure drop is induced at the low fuel pressures. The reduction of rate is a func-

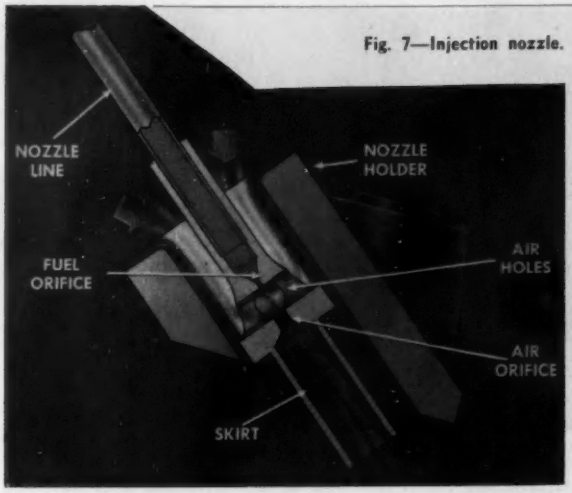


Fig. 7—Injection nozzle.

Nozzles are fed by individual tubes, which are either soldered or attached by a tube fitting. If threads are added to nozzle they are external so that tightening chases chips away from tube joint.

Fuel flows from between two lands of spill sleeve to either one or two distributors and then to each nozzle. It is important to make all connections so as to eliminate entry of foreign matter and also to protect all lines from absorbing heat by radiation or conduction. Inside diameter of nozzle line is 0.049 in. All fuel passages are controlled so that nozzle orifice is only significant restriction. This permits minor line length variation and sharp bends without affecting fuel distribution. Obviously, nozzle plugging is a possibility, theoretically however, one nozzle may plug completely or partially without interfering in slightest with metering of remaining nozzles.

Note that metal-to-metal contact of nozzles with engine parts is prevented by insulating nozzle holder and by air space surrounding nozzle skirt. Cumulative effect of this change is ability to maintain idle operation even after engine coolant may have reached boiling point.

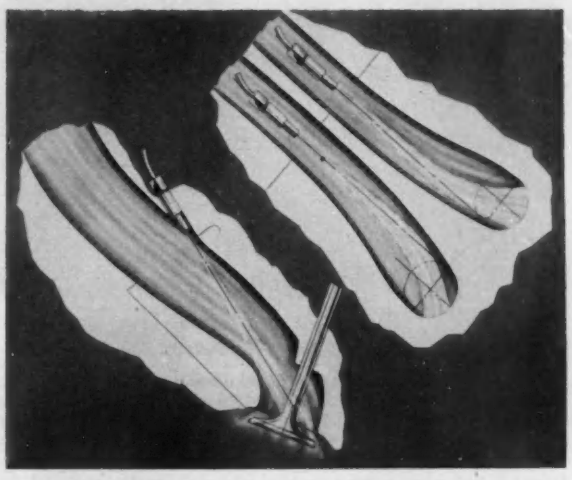


Fig. 8—Nozzle aiming.

Nozzle location, in terms of its distance from cylinder-head intake port, direction of spray, and its relation to passing airflow, has significant bearing on dynamic performance, and on the ease of cold starting and warmup. It is evident that the farther the nozzle is removed from the port the more it will resemble the carburetor in dynamic operation.

It appears, therefore, that nearness to intake valve is desirable and nearest convenient location for nozzle outlet is at juncture between cylinder head and manifold.

In regard to aim of the nozzle, above considerations suggest an aim which avoids walls and is directed at intake valve itself. Furthermore, it seems desirable to direct fuel toward periphery of valve rather than on valve stem, particularly in case of Chevrolet port layout, which imparts moderate rotary motion to incoming air. Aim and location of nozzle in respect to the airstream is shown above. Nozzle is placed in a local indentation to combine necessary intrusion with minimum protrusion, and expose nozzle skirt to tangential airstreams.

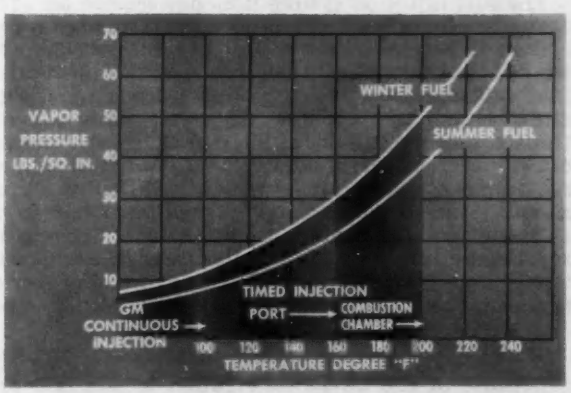


Fig. 9—Average nozzle operating temperatures.

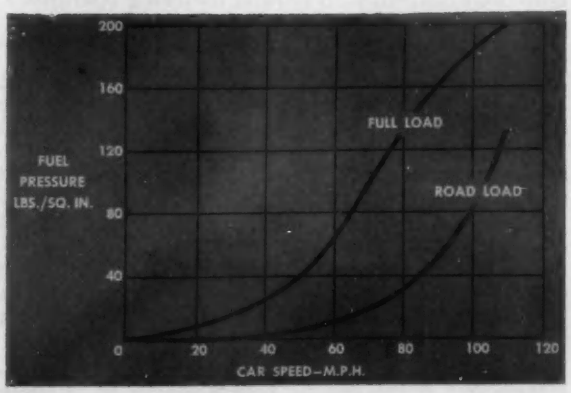


Fig. 10—Fuel pressure versus car speed.

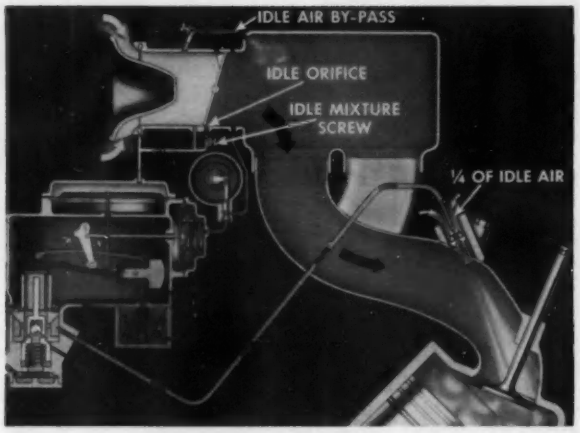


Fig. 11—Idle operation.

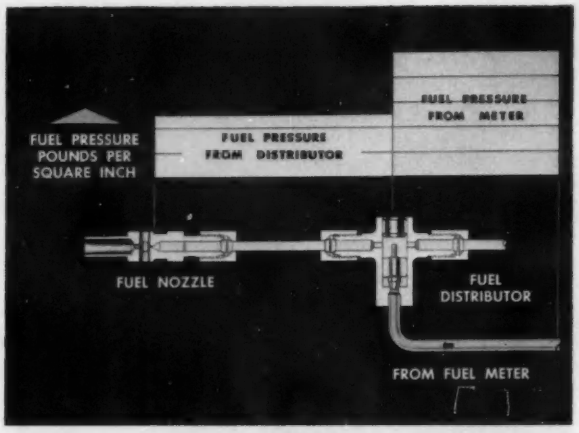


Fig. 12—Reduction of idle fuel rate.

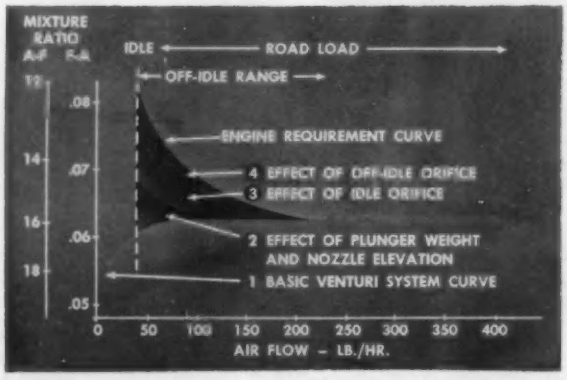


Fig. 13—Idle and off-idle mixture ratios.

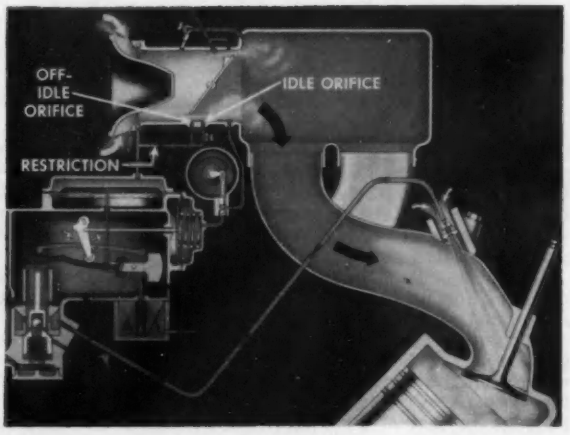


Fig. 14—Off-idle enrichment.

tion of balance between the check needle weight in the fuel distributor and its exposed area on the pressure side of the line. At pressure higher than idle fuel pressure the check valve is lifted off its seat and does not interfere with normal metering operations.

Off-Idle Enrichment

To give best economy for steady-state operation at idle and off-idle, the engine requires a mixture which is richer than for higher speeds (Fig. 13). The basic venturi system results in a leaner mixture at low airflows but, because of the plunger weight and the nozzle placement below the spill level in the fuel meter, there is some inherent enrichment near idle. The remainder of the required idle mixtire enrichment is supplied through the idle orifice and the remainder of the enrichment required in the off-idle range is supplied through the off-idle orifice (Fig. 14).

As the throttle is opened from the idle position, the off-idle orifice is subjected to manifold vacuum, thereby intensifying the venturi signal. The amount of off-idle bleed is regulated by the restriction in the bleed passage.

Transients

The fuel injection system does not require an accelerator pump to supply extra fuel during throttle opening transients. Two factors are responsible for the elimination of the accelerator pump: (1) manifold wetting is kept to a minimum by port injection, and (2) instantaneous fuel meter response. Upon throttle opening, the manifold is filled by an immediate inrush of air greater than the stabilized air requirement, causes an equivalently larger venturi signal. Since the fuel meter linkage parts are very light and the travel small, their inertia is negligible so that the inrush of air will instantly cause a rise in fuel pressure. The result is a shot of fuel proportional to the inrush of air.

Cold Start and Warmup

Because of the direct distribution of the fuel to the intake ports, it is not necessary to provide a sub-

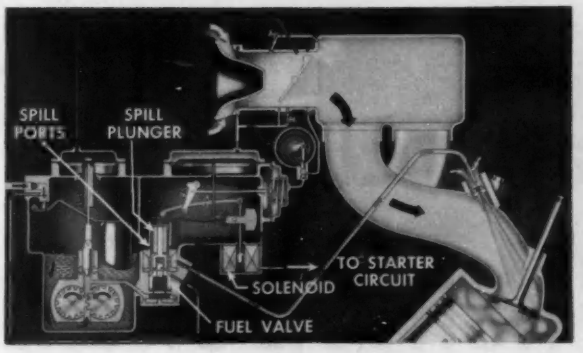


Fig. 15—Cold starting.

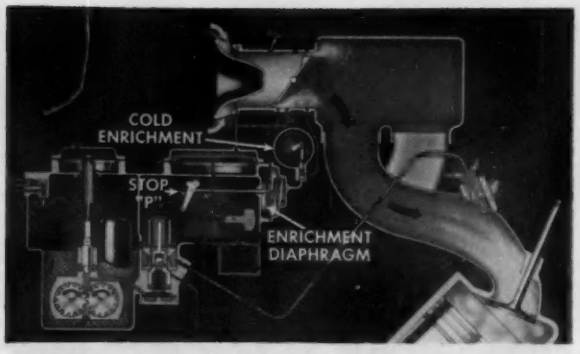


Fig. 16—Warmup enrichment.

stantial fuel enrichment to wet and flush the manifold as is the case with a carburetor. The starting enrichment required is achieved by means of a solenoid connected to the starter circuit. This solenoid (Fig. 15) forces the plunger down far enough to unseat the fuel valve. This action results in: (1) completely cutting off the spill by covering the spill ports, and (2) uncovering a passage from the float chamber inlet to supply extra fuel directly from the diaphragm pump.

During warmup the cold enrichment mechanism keeps the ratio lever at the power stop position (Fig. 16) by cutting off manifold vacuum to the enrichment diaphragm (Fig. 17). This enrichment assures solid steady-state engine operation during warmup. By directing the fuel stream upon the intake valve, the incoming mixture is warmed up considerably faster than by means of the "hot spot" of the intake manifold of the carbureted engine. A fast idle cam keeps the engine idle speed high enough to eliminate stalling by slightly opening the throttle blade during warmup.

Coasting Shutoff

The fuel injection system operates with dry manifold, and consequently, the amount of fuel vaporization in the manifold during deceleration at closed throttle is negligible. A further step to eliminate exhaust fumes containing unburned fuel during coasting is provided by a coasting shutoff (CSO, Fig. 18) located directly above the gear pump outlet, and consisting of a valve, which under normal operating conditions is closed by a spring. A CSO link connects the valve to the CSO diaphragm, which is subjected to manifold vacuum at the throttle body. During coasting, high manifold vacuum exerts a force on the diaphragm in excess of the spring load, and the pull rod lifts the valve off its seat, thereby allowing the pump to discharge directly back into the float chamber, no fuel flowing to the nozzles. The vacuum valve is so arranged that vacuum can be applied to the diaphragm only when the throttle is closed to eliminate CSO action as the engine is accelerated at no load.

(Paper "General Motors Fuel-Injection System" on which this abridgment is based is available in full from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

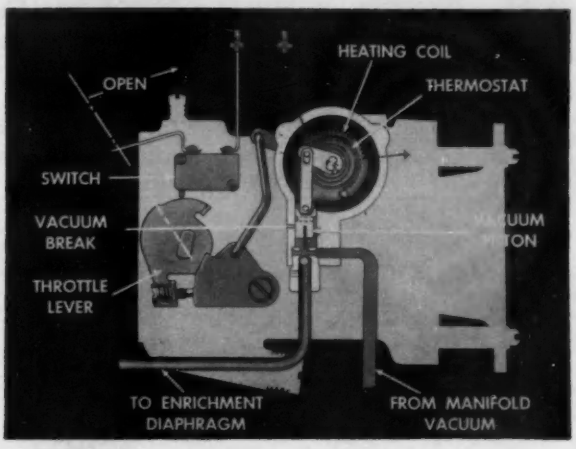


Fig. 17—Details of enrichment mechanism for cold operation.

Manifold vacuum applied to power enrichment diaphragm is taken through cold enrichment housing. Vacuum, normally applied to thermostat piston, also acts to seat ball valve below, which blocks diaphragm passage. This produces richer mixture for cold light-load operation. As ambient plus thermostat-heater temperatures rise, piston is permitted to move and protruding pin unseats ball. Finally, as cold enrichment becomes unnecessary, full manifold vacuum acts on enrichment diaphragm to regulate ratio-lever position, and piston seals its own vacuum supply passage.

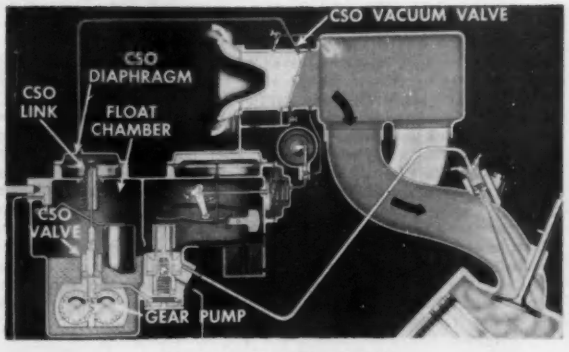


Fig. 18——Coasting shutoff.

Electronic Bendix

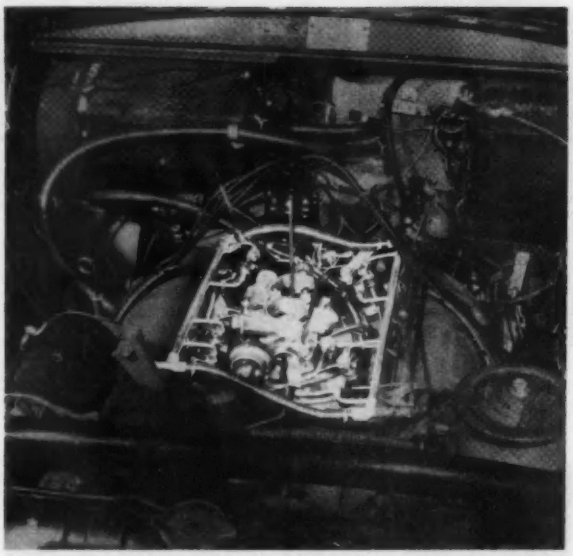


Fig. 1—Bendix Electrojector fuel-injection system installed in passenger-car engine.

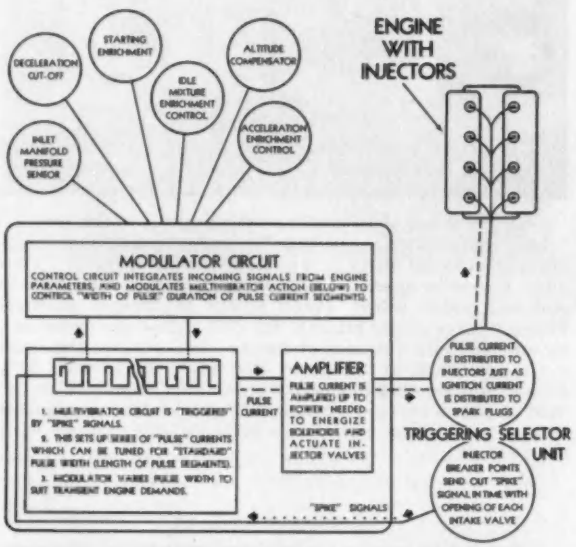


Fig. 2—Schematically indicated here are the various items and sensing units of the control system. Cycle of operation is as follows:

As engine rotates, injector breaker points send out spike signals in time with opening of each intake valve to electronic modulator unit. Multivibrator circuit in electronic control box is triggered by spike signals. This sets up a series of pulse currents tuned to standard pulse width. Standard pulse segments are then subject to modification by various modulating or sensing circuits: inlet manifold pressure sensor, deceleration cutoff sensor, starting enrichment control, idle mixture enrichment control, altitude compensator, and acceleration enrichment control. This modified impulse is then transferred to amplifier, where pulse current is amplified to power needed to energize and to actuate solenoid injector valves. This amplified electrical pulse is then directed to selector, where it is distributed to proper fuel injectors, just as ignition current is distributed to various spark plugs. Injectors then react to power impulse, causing valve to lift from seat and permit required fuel to flow to cylinder.

THE Bendix Electrojector (Fig. 1) is an electronically controlled and electrically actuated (Fig. 2) fuel-injection system for passenger cars.

It has timed intake port injection and a low-pressure, 20-psi common-rail fuel system. It employs controls that are responsive to intake manifold pressure, engine speed, air pressure, and temperature.

Fuel Supply System

Fig. 3 indicates the basic fuel supply system in which fuel is drawn from the fuel supply tank by an electrically driven, nonmetering, fuel supply pump that maintains the line pressure to the fuel-injector valve, of which there is one for each cylinder of the engine, at 20 plus or minus ½ psi. Between the fuel pump and the injector is a fuel filter. It is not necessary to filter the fuel finer than 20 microns particle size as the system does not have close-fitting mechanically operating units. Experience to date

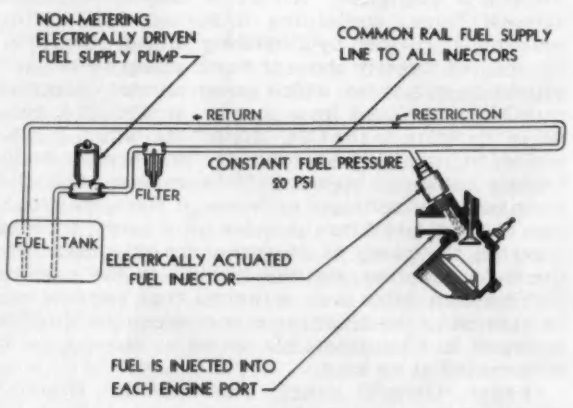


Fig. 3—Basic fuel supply system.

Brain Controls Fuel-Injection System

Excerpts from paper by **A. H. Winkler and R. W. Sutton**
Eclipse Machine Division, Bendix Aviation Corp.

has indicated that the best results are obtained when the fuel is directed at the head of the intake valve so that a minimum amount of wall wetness results. A fuel return line is incorporated in the system to purge any air or fuel vapor continually from the fuel supply system. To date, we have not experienced any engine malfunctioning due to air or fuel vapor in the lines, even though the system has been subjected to high underhood temperatures and empty fuel lines during a shutdown period.

The solenoid fuel-injector valve is shown in Fig. 4. Fuel enters at the top of the unit and passes through the center core of the valve, discharging through the nozzle at the lower end when the injector valve is off its seat or open. Considerable experimental work and testing were done on this valve and solenoid assembly to realize a unit that could operate at high speed, maintain calibration, require low power for operation, and be manufactured at a reasonable price. This, like other units in the system, is new, when compared to carburetor experience, and is continually undergoing changes for improvement in operation and ease of manufacturing.

Triggering Selector Unit

Timed fuel injection is used. To a standard engine distributor, a fuel-injection triggering selector unit and rotor are added. They are inserted as a sandwich between the base of the distributor and the standard ignition distributor cap. In the triggering selector unit, there is a set of breaker points and a distributing commutator with a section of the commutator for each solenoid injection valve.

The breaker points are actuated by the same cam that operates the regular engine ignition points. Thus, for each two revolutions of the engine, the fuel-injector breaker points have made and broken contact the same number of times as there are cylinders in the engine. Each time the fuel-injector

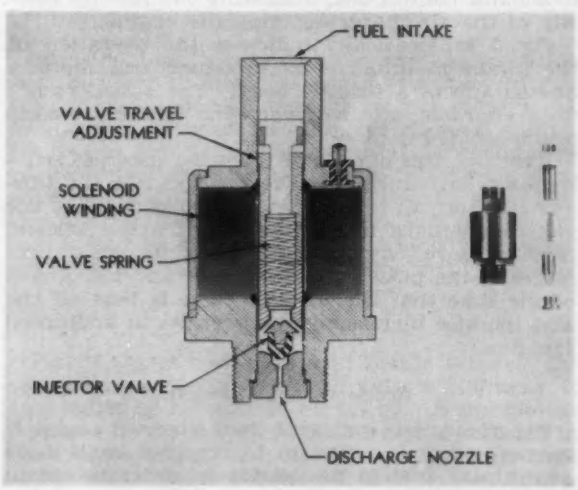


Fig. 4—Fuel injector.

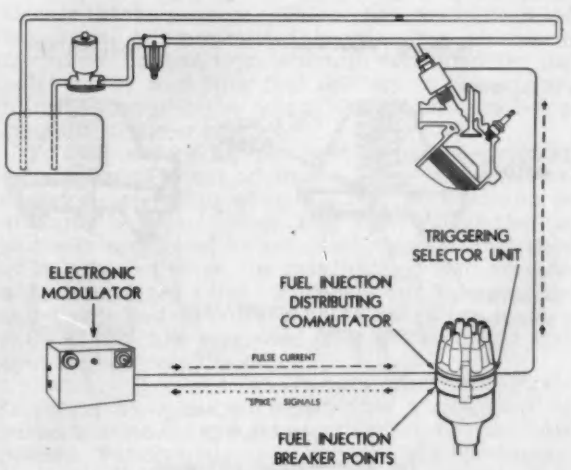


Fig. 5—Injection timing and injector actuating elements.

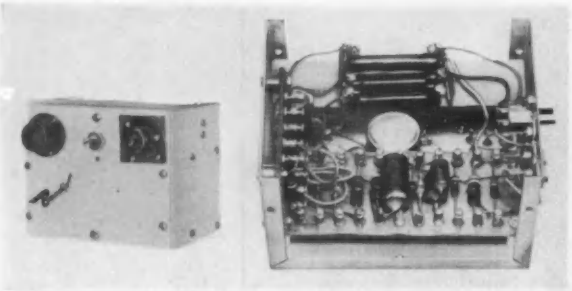


Fig. 6—Electronic modulator.

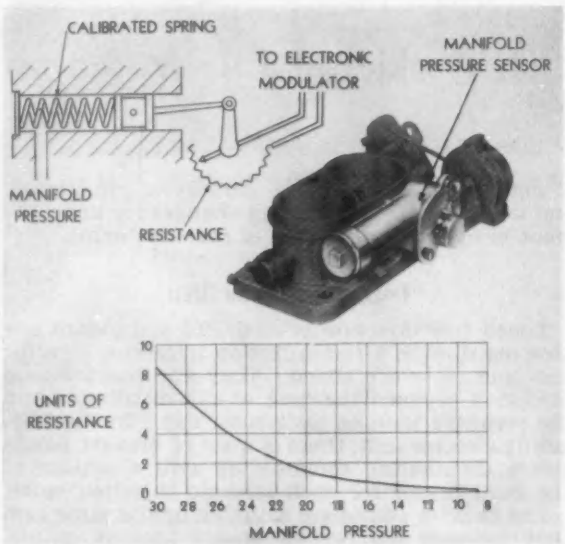


Fig. 7—Intake manifold pressure sensor.

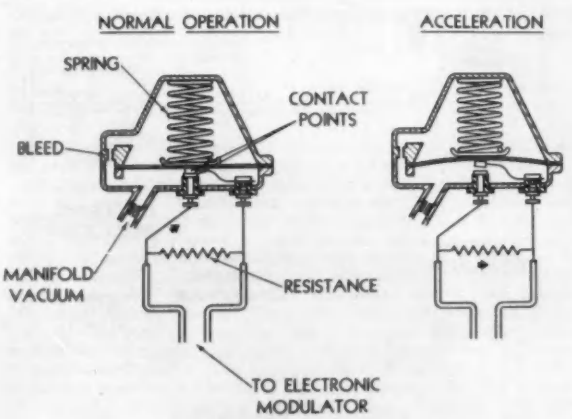


Fig. 8—Acceleration enrichment.

breaker points make contact, a triggering impulse is transmitted to the electronic modulator box. After which, the modified signal is returned to the selector portion of the assembly and the impulse is distributed to the correct fuel-injector valve. Fig. 5 illustrates how the electronic modulator control and triggering selector units are arranged in the system. Through the triggering selector unit, engine speed and fuel-injection timing are sensed and the electrical impulse is correctly distributed to the individual fuel injectors. Because the commutator segments neither make nor break the electrical circuit in the system and the electrical energy transmitted by the breaker points is low, very acceptable operating life is expected from this unit. This simple distributor modification is the only change necessary in the engine drive system to adapt it to the Electrojector system.

Electronic Modulator

The first function of the electronic modulator control or brain box is to transform the spike signals received from the triggering selector unit into an electrical pulse of a given standard width. Simultaneously, signals indicating engine operating conditions are also being received by the electronic modulator control from sensing units located on various parts of the engine. By integrating these external sensing signals into the standard pulse width circuit of the electronic control system, the standard pulse width is modified to reflect engine conditions. This modified electrical pulse is then transmitted to the selector portion of the triggering selector unit, which in turn distributes or directs the pulse to the correct fuel injector.

The control (Fig. 6) uses transistors instead of vacuum tubes because, unlike tubes, they require no warmup time and draw a very low current from the battery.

Manifold Pressure Sensor

Standard-type, but larger, throttle valves are used to control the airflow to the engine. Attached to the throttle body is an intake manifold pressure sensor that transmits a signal to the electronic modulator control box, indicating the relative density of the air charge entering the engine.

Fig. 7 schematically indicates the operation of the intake manifold pressure sensor and shows a photograph of a throttle body. The actual resistance characteristic will vary for different makes and models of engines.

Basically, this and all of the other external sensing units introduce added resistances into the fundamental circuit to modulate the pulse width of the electrical impulse that is transmitted to the solenoid injector valve. As the sensing circuits' resistances increase, the pulse widths increase and the length of the time that the injector valve is held off the seat likewise increases, which results in additional fuel flow.

Acceleration Enrichment

Experience has indicated that, when an engine is accelerated, it is necessary to supply a small extra quantity of fuel to the engine in order to obtain smooth engine operation during this transient pe-

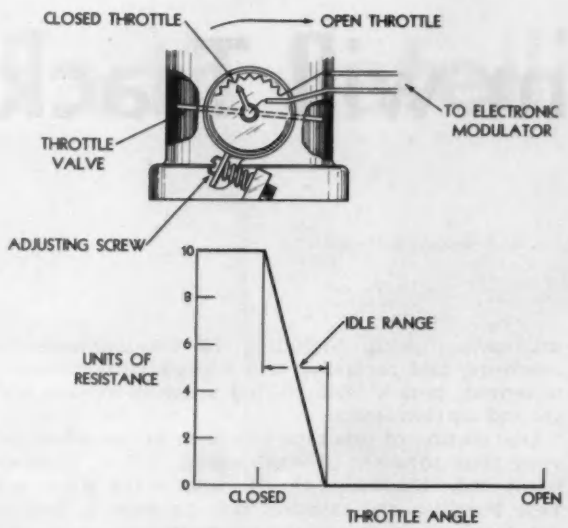


Fig. 9——Idle enrichment.

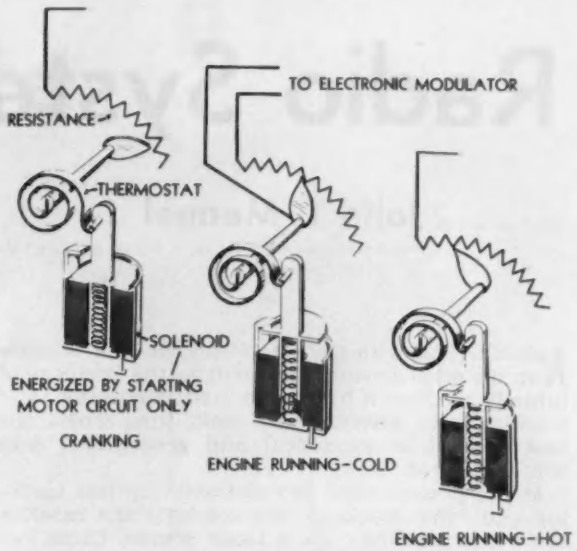


Fig. 10—Starting enrichment.

riod. Fig. 8 illustrates one method of accomplishing this temporary enrichment through a manifold vacuum change sensing device. In operation, a rapid change in manifold vacuum will cause the points to separate and introduce an additional resistance in the control system thus increasing the operating pulse width of the electrical signal for the length of time necessary to equalize the pressure in the chambers on both sides of the diaphragm in the unit. The added pulse width will increase the fuel flow from each injector inasmuch as the injectors will be energized for a longer period of time during this transient period. We are also considering alternate methods such as mechanical operation through the accelerator or throttle linkage.

Idling Enrichment

Smooth idling is important in any car operation and, in order to meet the slight variations in fuel requirements between engines of the same make and model, a separate idle enrichment control (shown in Fig. 9) is incorporated. A rheostat is connected to the throttle shaft to interject a variable resistance in the control circuit when the throttle is in the idle position. The idle adjustment is obtained by adjusting this resistance instead of the conventional idle mixture adjustment needle.

Cold Starts

Fig. 10 shows how additional fuel is supplied for cold-weather starts and how this enrichment is diminished as the engine warms up. A thermostat positions a variable resistance such as a rheostat in the control system that will increase the resistance as the temperature diminishes, thus increasing the pulse width with decreasing temperatures. To obtain the added fuel flow during the cranking period, an electric solenoid operating through the thermostat repositions the rheostat to a higher resistance position during the cranking period. Since the thermostat reflects engine temperature, the amount of enrichment decreases as the engine warms up. This signal, like the others, is transmitted to the electronic modulator box for integration with the other signals.

A conventional fast-idle cam and thermostat mechanism provide the necessary fast-idle speeds during the warmup period.

An additional refinement in temperature control can be obtained by inserting a thermistor that senses the actual air temperature being supplied to the engine during normal temperature operation in the air intake passage. This signal, in the form of resistance, is transmitted back to the electronic modulator control unit, which in turn modifies the pulse width, and thus fuel delivery to the engine, in relationship to the actual air temperature being supplied to the engine.

To help reduce air pollution it has been found advantageous to cut off the fuel flow to the engine during deceleration when the manifold vacuum is abnormally high. Since fuel flow modulation is partially controlled by manifold vacuum, fuel cutoff is attained when the manifold vacuum exceeds a predetermined value. With the fuel injectors located adjacent to the intake valves, there is very little, if any fuel carryover from the manifold and thus a clean cutoff is effected.

(Paper, "Electrojector—Bendix Electronic Fuel-Injection System," on which this abridgment is based, is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Radio System will Track

Based on talk by **John T. Mengel**
Head of Tracking and Guidance Branch of Project Vanguard, Naval Research Laboratory

ASSOCIATED with the establishment of a satellite in an orbit around the earth is the problem of initially spotting it by ground instrumentation, and tracking it to determine its orbit, from which the vast amount of geodetical and geophysical data will be derived.

At the present time two methods—optical tracking and radio tracking—for tracking the satellite are being pursued. To a large degree, these two methods are complementary, each fulfilling a separate and important phase of the tracking problem.

The **radio** system is being relied on to provide the initial acquisition of the satellite, and to provide data from which the optical tracking units can determine the time, direction, and traverse rate information required to permit them to track the satellite.

The **optical** system will presumably provide more precise angular data on the satellite position, but only when sun position, satellite position, and ground optical tracking position are all in a favorable relationship.

The radio system will provide tracking data day or night, in clear or cloudy weather—indeed under any weather conditions, excluding possibly severe local electrical storms. However, the radio system will provide tracking data only as long as its battery supply lasts, a period of several weeks. This is time enough to determine the satellite's orbit. The optical system will provide continuing tracking data as long as the satellite is in its orbit.

The radio system to be used in conjunction with the tracking of the Vanguard satellite program is the Minitrack System, developed by the Naval Research Laboratory. ("Minitrack" stands for minimum weight tracking.) This system utilizes an active continuous-wave radio transmitter within the satellite package to illuminate pairs of ground receiving antennas which are oriented precisely in a prescribed arrangement. Measurement of the difference in the phase of the signal arriving at one antenna of a pair compared to the phase at the second antenna of the pair provides a measurement of the angular position of the transmitting source relative to the line connecting the two antennas.

The Minitrack System, once it is established, will serve each satellite launched as part of Project Vanguard.

A Prime Minitrack Station will be a complete station including the Minitrack ground antenna configuration, a complete Minitrack Electronic Unit mounted in its own air-conditioned trailer, a communication setup including 15 kw transmitters, receivers, and receiving and transmitting rhombic antennas, plus a telemetering antenna system and ground station units.

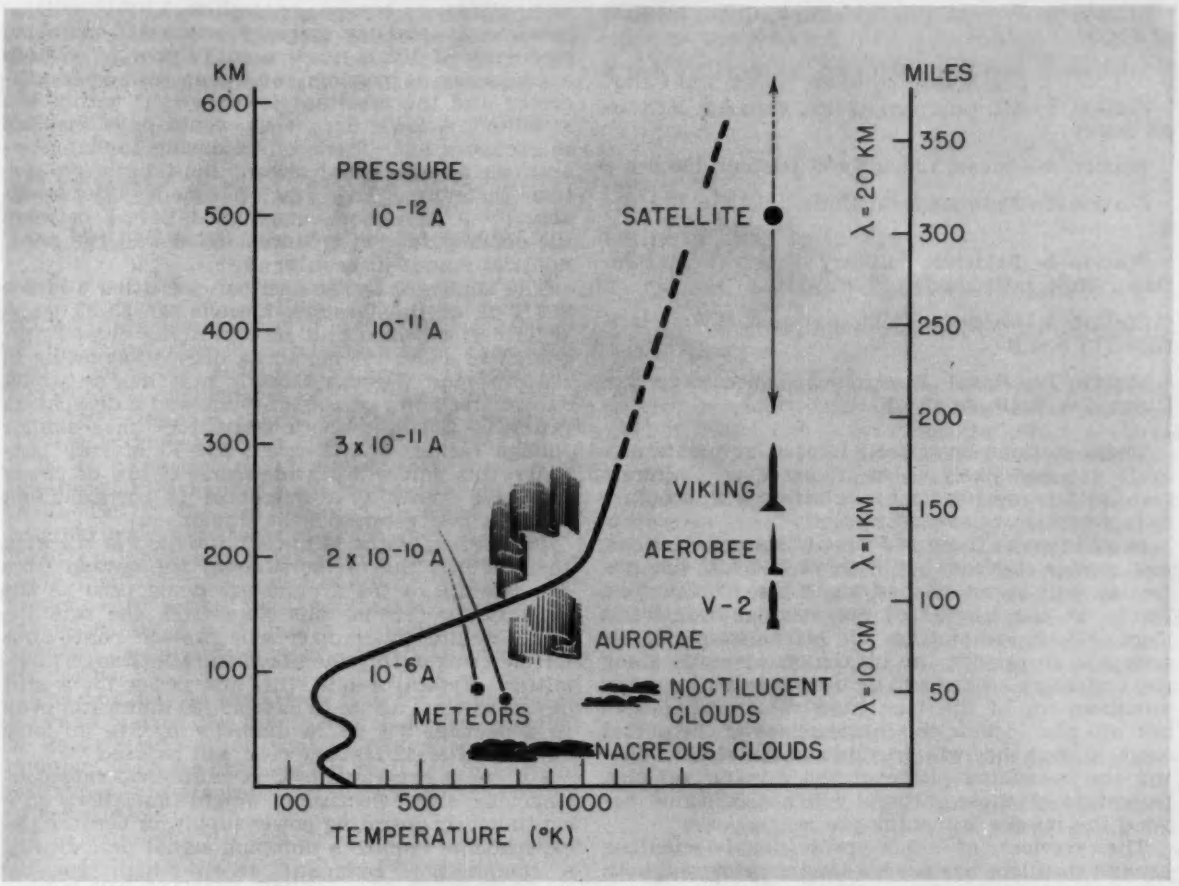
One station of this type has been in operation for some time adjacent to Washington, D.C. at Blossom Point, Md. Known as the Blossom Point Minitrack Test Facility, this station will provide a testing point for all of the prototype units produced, and an evaluation point for all final units. Inasmuch as the function of this station differs from the other stations in its initial application, its layout is unique. For example, its antenna configuration utilizes 14 antenna arrays to provide simultaneous evaluation of two types of antennas. Also, because of its proximity to the Digital Computation Center in Washington, telephone communication is provided, rather than a radio link as the other stations will have.

A different type of Minitrack System, the Mark II System, has been designed to provide a means of measuring the satellite orbit at more numerous locations around the earth, and thereby measure the precise location of the stations with reference to the complete geodetic system of the earth. This system uses a simplified electronic system, and as few as two antennas to provide time-of-transit information from the satellite passage. This system is designed to operate in conjunction with the Prime Minitrack Network, utilizing the data from this network for ambiguity resolution, thereby eliminating the need for more than four antennas for complete measurement of the satellite passage.

This system is designed for use by universities, professional groups, and advanced amateur radio clubs throughout the world. It is felt that it will be suitable for obtaining accurate and useful information at many locations where complete Prime Minitrack Stations are not feasible. A prototype of a complete Mark II Minitrack Station is being built by the U.S. Naval Research Laboratory. Drawings and data from this prototype unit will be made available to any prospective user of this type of system, in an effort to increase the total number of Minitrack measurements around the world. Its use is invited by participants anywhere in the world between the limits of 40 deg S and 40 deg N latitude, particularly in Australia, Africa, Southern Asia, and Eastern South America.

The Mark II Minitrack System is based on the use of phase comparison techniques between the two radio frequency signals received.

Earth Satellite



SATELLITE WILL REACH ALTITUDE OF 300 MILES then orbit around the earth for two weeks or more, it is hoped. At this altitude temperatures are high but air molecules are so scarce that air temperature alone doesn't mean much. Satellite will be boosted by three rocket stages, a V-2, an Aerobee, and a Viking.—Official United States Navy illustration.

The complete Mark II system for a single antenna pair includes a radio frequency hybrid junction fed directly by the two antennas, two low-noise 108 mc amplitude modulation receivers using a common local oscillator, a product detector, an audio amplifier, a recorder unit suitable for recording at least two and preferably four channels of data, plus time, a time standard receiver, and the required antennas. For those locations not close enough to receive the WWV, WWVH, or other standard time signals consistently, an auxiliary precision crystal clock unit is desirable to guarantee the availability of standard time during every tracking event.

In effecting a program utilizing this radio system, an integrated arrangement of stations is being utilized so that a north-south fence line of Prime Minitrack Stations is provided. Assuming a median satellite altitude of 300 miles, each station will receive a signal from the satellite whenever it is within ±300 miles or less of the station in the north-south direction. The total north-south distance to be covered by the satellite at orbital inclinations of up to 40 deg is about 5500 miles. Thus, a total of nine stations should provide nearly 100% intercept probability for the satellite.

Actually, eight stations are to be provided in the basic north-south fence, ranging from a latitude of 32 deg south to 38 deg north, providing a probability of intercept within this region of over 95%. Two additional stations will provide initial acquisition and orbital determination during the first orbit, one on the island of Antigua within the Air Force Missile Test Center test range, 1500 miles down range from the launcher, and the other at San Diego, Cal., to provide pickup data approximately 85 min after launch. These stations are referred to as the Prime Minitrack Stations, each station being a complete Minitrack station with all

ambiguity resolution provisions and with the highest accuracy components. The locations of these 10 Prime Minitrack Stations are:

Station 1—Blossom Point, Md., latitude 38.4 deg N

Station 2—Fort Stewart, Ga., latitude 32 deg N

Station 3—Batista Field, Havana, Cuba, latitude 23 deg N

Station 4—Rio Hato, Panama, latitude 8.5 deg N

Station 5—Mt. Cotopaxi, Quito, Ecuador, latitude 0.6 deg S

Station 6—Ancon, Lima, Peru, latitude 120 deg S

Station 7—Antofagoasta, Chile, latitude 23.3 deg S

Station 8—Peldehue Military Reservation, Santiago, Chile, latitude 33.2 S

Station 9—Coolidge Field, Antigua, B.W.I., latitude 17.1 deg N

Station 10—Naval Electronics Laboratory, San Diego, Cal., latitude 32.5 N

These stations have been located at points aircraft are not likely to be flying over. Aircraft transmitters overhead could interfere with accurate data reception at ground stations.

In addition to these 10 Prime Minitrack Stations, two similar stations, but without the full size antennas, will be established along the AFMTC Test Range at the islands of Mayaguana and Grand Turk. These two stations will utilize simple dipole antennas to provide the maximum coverage along the trajectory. They will be used primarily for the measurement of the launching vehicle operation, but will also include the initial phase of the actual orbit, so that they will provide additional data during the launching phase of the mission vehicles. Operation of these stations will not continue beyond the missile launching phase.

The services of other professional scientists around the globe are needed for this program, both with regard to the Prime Minitrack Stations and the Mark II Minitrack Stations. The locations for the Prime Minitrack Stations have already been selected, so that the regions from which professional scientists could make their services available are fixed. In these areas, namely Chile, Peru, Ecuador, Panama, and Cuba, the services of scientists are welcomed, either as non-operating observers to satisfy their interests in the application of the equipment to the problems of geodesy and geophysics, or as participating operators in the program. For these stations, the complete station units will be provided by the U.S. as a part of the Vanguard program.

With regard to the Mark II Minitrack Stations, detailed system information and data will be provided to any group demonstrating a bonafide intent to establish such stations. To a limited degree, consultation on station establishment, operation and design aims will be provided by the Naval Research Laboratory. In addition, for those locations that can demonstrate sufficiently precise installations, including both station electronics and antenna surveys, calibration teams may be provided periodically to guarantee the accuracy of the data from the stations. The data from such stations would then be used in the overall orbital determination to be provided by the Vanguard Digital Computer at the Washington, D.C. Central Computation Facility.

The Minitrack Transmitter within the satellite will utilize a crystal controlled VHF oscillator powered by Mallory mercury cells. An operating frequency of 108.00 mc is used, to provide as high a frequency as possible consistent with good efficiency and the resultant lower weight within the satellite. A lower frequency would have resulted in excessive ionospheric effect during tracking operations, an effect that already limits ultimate system accuracy. The exact frequency chosen is actually a heretofore unassigned parcel between the commercial FM broadcast band and the aeronautical marker beacon band.

The Minitrack transmitter can use either a Philco SBDT-12 or the Western Electric GA-53233 transistor. The Philco unit has an alpha cut-off frequency of above 150 mc and a dissipation rating of 100 mw; the Western Electric unit has an alpha cut-off frequency of about 540 mc and a dissipation rating of 200 mw. Both transistors have similar voltage ratings. With seven RM-12 Mallory batteries, this unit will provide about 15 mw of power for three weeks at a weight of 13 oz, excluding antenna and external heat shields.

In addition to the Minitrack function of tracking the satellite, the r.f. portions of the system from the satellite to the ground are being used as the r.f. link for telemetering data from the satellite. The satellite transmitter will provide continuous telemetering during the life of the Minitrack Transmitter. Typical weight, life, and power for a unit of this sort are 5.5 lb, 16 days at 100 milliwatts peak in a package $3\frac{5}{8}$ in. in diameter by $5\frac{1}{2}$ in. long. Fourteen RM-42 Mallory cells will be used.

For those experiments that cannot operate continuously, either because of weight limitations on a continuously operating power supply, or because the experiments require a dumping signal periodically, a combination command receiver-high powered modulated transmitter will be provided in addition to the normal low-powered Minitrack Transmitter.

An operating range of 4800 miles is calculated for a post-detection signal-to-noise ratio of 30 db, corresponding to 1.8 deg of phase resolution. This phase resolution corresponds to a space angle resolution of 0.1 milliradian, or 20 sec of arc. This value may be limited by the effect of the ionosphere and troposphere in refracting the radio signal prior to its arrival at the receiving antenna. Such effects may be constant errors which are a function of zenith angle, or a phase noise which is a function of ionosphere or troposphere turbulence. The presently estimated magnitude of these effects is under 20 sec of space angle at small zenith angles during passage late at night, to over 1 milliradian (200 sec) during daytime passages at large zenith angles.

To calibrate the Minitrack System, a method of calibration using optical techniques will be used. A special polar-mounted camera using an f/5.0 40 in. ultra-linear lens will be mounted at the exact three dimensional center of the Minitrack antenna

configuration. During nighttime operations, a high flying airplane will carry a Minitrack transmitter together with a radio-controlled flashing light that is commanded to flash about every second from the ground Minitrack station.

When this plane is flown across the Minitrack antenna beam, the camera photographs the position of the flashing light on the plane against the star background, thereby permitting post-flight reduction of the photographic image to provide the airplane position to the order of 2 sec of arc. Such calibration runs will be made about every two weeks at each tracking station, using specially trained calibration teams.

More frequent checks of the Minitrack System will be obtained by measuring the position of the sun and several of the radio-stars by using them as radio sources of calibrated position. Unfortunately, their angular sizes are too gross to give the ultimate system precision required, but significant information in the field of radio astronomy may be obtainable in this way.

(This abridgment is based on a talk entitled "The Minitrack Radio Tracking Program.")

Attack on Costs . . .

. . . to be successful involves organization, training, and follow-up.

Based on talk by **Roger Hubbel,** Allis-Chalmers Mfg. Co.

THE variation in amount of cost reduction between the casual "do-it-as-you-have-time" approach and a concerted, organized approach staggers the imagination. Whichever of the varied avenues to cost reduction are taken, a concerted, organized drive must be behind the effort.

To be successful, an attack on costs must have organization, training, and follow-up. It should make use of ALL employees . . . wage earners, whether operators, assemblers, or clerical workers; industrial engineering personnel, responsible for such functions as material handling, methods and systems engineering; plant engineering, and organization planning; and finally, the bulk of the management group, including supervisors and technical specialists.

The first step in the attack is to fix responsibility for coordinating the function to a single individual or department. Then that individual must make detailed plans for carrying out both the training of participants in program and the actual cost-cutting program itself.

The training of the various groups and people who are to participate is an essential prerequisite to effective cost-reduction action. The big problem, in other words, is to transfer a nebulous general responsibility into concrete proposals. Then to develop and put those proposals into effect.

The DETAILED PLANS must be sold to all levels of management so that their close support is obtained.

Major items which should be included in training for a cost-cutting attack include the following:

1. Basic information on our competitive economic system;
2. Basic information on the location of cost data within the organization;
3. Provision for an attack on the four principal areas of cost . . . methods, materials, part simplification, and burden expense;
4. Provision of a systematic approach for analyzing any problem through use of process charts, multiple activity charts, and flow diagrams;
5. Provision of information on selling ideas and enlisting the cooperation of others;
6. Make sure that each "participant" works on a specific problem, selected from his own department.

Two basic human characteristics have to be considered in undertaking any cost-reduction program. One is desire for recognition; the other, a strong tendency to give a negative answer to a recommendation before it has had due consideration.

Recognition must be given to the employee who does good work. Education of management to recognize this must be continuous. But, in addition, reports should be submitted by the coordinating group on outstanding work. Records should be kept on individual accomplishments and used as the basis for promotions and other forms of recognition.

No idea received by the coordinating group from a supervisor should be rejected without a reasonable explanation.

No program can withstand:

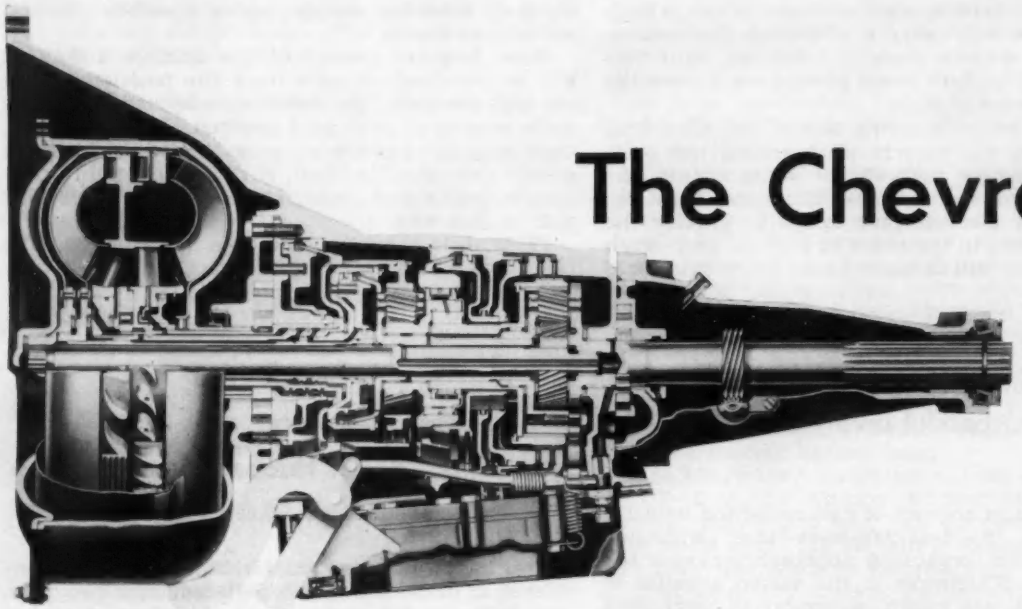
a. A closed-mind attitude on the part of supervisors;
b. A hasty brush-off by any person or group involved by any other person or group involved;
c. Lack of support from top management for recommendations growing out of the attack.

Business is getting more complex every day—whether the organization be a large or a small one. Management must grow with it. Every organization has only two choices: to remain competitive or to be forced out of business. An effective cost reduction program may be the key to whether or not a given company is able to survive in a competitive market.

(The report on which this article is based is available in full together with reports of 7 other panels of the 1956 SAE Tractor Production Forum. The complete report (SP-316) is available from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3 to nonmembers.)

(Panel members: R. M. Bruesewitz, Power Products Corp., leader; R. A. Dimberg, Allen-Bradley Co., secretary; F. M. Hunt, Evinrude Motors Division of Outboard Marine & Mfg. Co.; Carl Rasmussen, Waukesha Motor Corp.; B. R. Zitner, Globe-Union, Inc.; Roger Hubbel, Allis-Chalmers Mfg. Co.; and N. J. Kimber, Wagner Iron Works.)

The Chevrolet



THE Turboglide is a nonshifting, concurrent-geared, multiple-turbine torque converter transmission with dual stator-blade control.

Turboglide has no low gear. It provides a competitive performance factor without manual or automatic shifting. Most important, it is unique in that the transmission performance ratio is available at any throttle position, allowing simultaneous modulation of torque ratio and engine output by depression of the throttle pedal alone.

There are, therefore, no "up-shifted" performance "holes" in city or hill climbing operation. Maximum engine and "normal" transmission performance converge smoothly at wide-open throttle. Further depression of the throttle pedal through a conventional "detent," changes the stator blade from the "normal" or "cruise" angle to the performance or passing angle.

With the Chevrolet 283 cu in. displacement, 4-barrel carburetor engine, the cruise angle stall torque ratio is 3.8/1 with an engine speed of 1700 rpm. Wide-open throttle coupling is attained at approximately 50 mph and 2700 engine rpm.

Performance angle stall torque ratio is 4.2/1 at 2600 engine rpm. Wide-open throttle coupling is reached at approximately 65 mph and 3200 engine rpm.

Part-throttle starts in cruise angle are "tight" and connected as a consequence of the low stall speed and high torque ratio. Actuation of the detent permits the blade change and consequent elevated engine speeds for maximum horsepower.

The Turboglide incorporates a 5-element torque converter, a pump, three turbines, and the dual stator. The torque converter operates in conjunction with two simple planetary gearsets. The three turbines are concurrently connected to the driveline at ratios of 2.67 for the first, 1.6 for the second, and 1.0 for the third. The first and second turbine reactions are grounded through one-way clutches to permit inactivation at the limit of their useful speed range.

Since an independent low range is not required, a grade retarder range is provided by gearing the first turbine at the 2.67 ratio in the conventional manner while permitting the second and third turbines to run free.

Reverse is accomplished by compounding the two planetary gearsets.

Drive, grade retarder, reverse, and neutral require the use of three cone clutches, one plate clutch and two one-way clutches.

Park augments neutral with a pawl and gear-type lock on the output shaft.

The shift quandrant seqnence is P, R, N, D, and GR.

The structural components, as well as many functional elements, are die-cast aluminum. The elimination of radial and bending loads through use of clutches rather than bands permits a compact and rigid design yet with relatively light construction. The absence of "power shifts" eliminates the requirement for calibration and timing functions thus greatly simplifying the control system and contributing to the over-all reliability factor.

The principle, general arrangement, and use of materials have resulted in a total installed weight of 148 lb as compared to an average weight of 241 lb for the industry's passenger-car transmissions.

Turboglide Arrangement

The Turboglide is a coaxial arrangement of the concurrent principle, requiring only one pump and stator and no input gearing.

For clarity the arrangement is illustrated in Fig. 1, as follows:

1. Turbine A is connected directly to the output shaft.
2. The "passing" turbine B is geared to

Turboglide Transmission

Based on paper by **F. J. Winchell, W. D. Route, and O. K. Kelley,** General Motors Corp.

the output through a simple planetary gearset at a ratio of 1.6/1. The input member is the ring gear with the output the carrier integral with the turbine A shaft while the reaction is the sun to ground through a one-way clutch.

3. The turbine C is geared to the output through an identical planetary gearset at a ratio of 2.67/1. The input now, however, is the sun; the output again the carrier and integral with both turbine A and the output of turbine B. The reaction is the ring to ground again through a one-way clutch.

Now that the order of elements in the flow path is established, the turbine will be re-identified according to SAE recommendations so that turbine C becomes T_1; turbine B, T_2; turbine A, T_3.

While now providing the necessary functions for forward operation the transmission lacks, for one thing, neutral.

T_3 is disconnected from the output by a cone clutch, as shown in Fig. 2. T_1 and T_2 are disconnected by releasing the ground members. This is accomplished through a series arrangement of the one-way clutches and a single cone to ground.

Park is provided by a pawl engaging a gear integral with the rear carrier.

Grade retard is accomplished (Fig. 3) by a 4-active-face-plate clutch which grounds the T_1 reaction, while freeing T_2 and T_3 through release of the forward and neutral cones. T_1 is thus geared at 2.67 times the output. Since the stator is freewheeling the reaction is against the engine only so that the propeller shaft torque is 2.67 times engine torque.

Reverse (Fig. 4) is accomplished by the addition of a ground cone on the second turbine, compounding the two planetaries for the reversal and reduction (1.78/1). The third turbine turns in the counter-engine direction with the output shaft. The second turbine is stationary and is a reaction member within the torque converter causing T_3 to be driven in the reverse direction, thus contributing to the total reverse output of 4.1/1.

The first column of these charts indicates the order of range selector sequence and is otherwise self-explanatory except that the term "carry" in the one-way clutch column is intended to explain that the clutch is not locked in the torque transmitting sense but is carrying the free outer race in the direction normally prevented by the application of the forward cone.

Performance

In the analysis of optimum torque distribution within the torque converter (Fig. 5), it is clear from the summation of the moments acting on the oil mass that for maximum performance the total available torque should be transmitted through the turbine having the largest gear reduction. This of course dictates "sequence" gearing and the resultant power shifts. If shifts are to be avoided the total available torque must be shared by the individual turbines with minimum torque to the lowest ratio turbines.

For maximum total output the direction of the

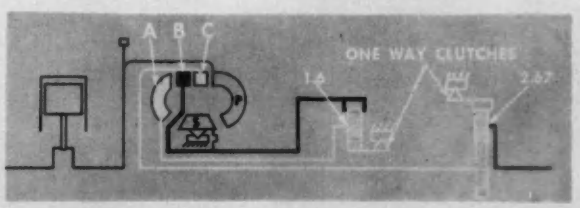
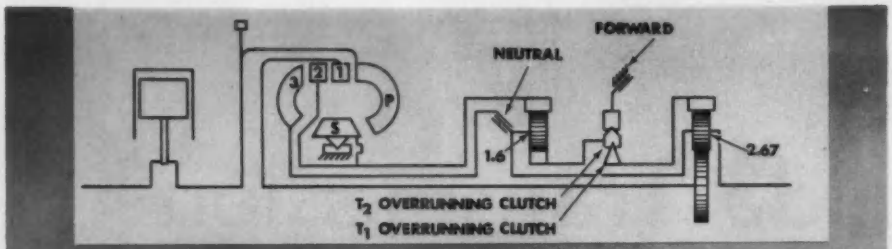
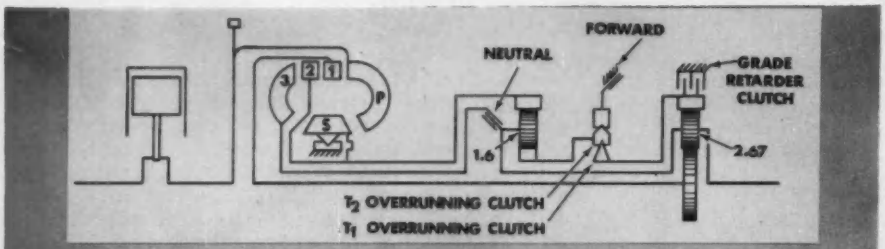


Fig. 1—Chevrolet's Turboglide arrangement. T_3, turbine A drives output shaft directly and provides cruising performance. T_2, turbine B drives through front planetary gearset and is predominant in middle or passing ranges. T_1, turbine C drives through rear planetary gearset and provides starting performance.



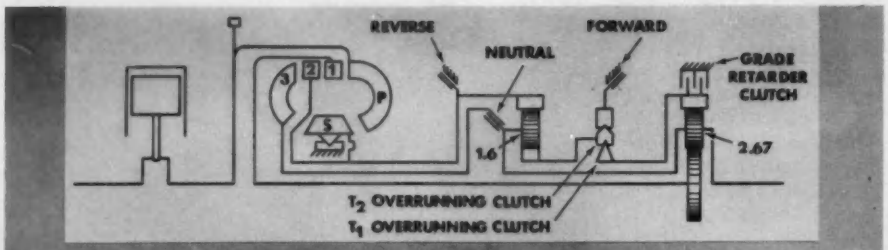
RANGE	NEUTRAL	—	FORWARD	—	T_1 OVERRUNNING CLUTCH	T_2 OVERRUNNING CLUTCH	GEAR RATIO	OVERALL RATIO
PARK	—	—	—	—	OVERRUNNING	CARRY	—	—
—	—	—	—	—	—	—	—	—
NEUTRAL	—	—	—	—	OVERRUNNING	CARRY	—	—
DRIVE	ON	—	ON	—	LOCK / OVERRUNNING	LOCK / OVERRUNNING	1.0 / 1.6 / 2.67	4.2 / — / 3.8
—	—	—	—	—	—	—	—	—

Fig. 2—Turboglide arrangement—neutral.



RANGE	NEUTRAL	—	FORWARD	GRADE RETARDER CLUTCH	T_1 OVERRUNNING CLUTCH	T_2 OVERRUNNING CLUTCH	GEAR RATIO	OVERALL RATIO
PARK	—	—	—	—	OVERRUNNING	CARRY	—	—
—	—	—	—	—	—	—	—	—
NEUTRAL	—	—	—	—	OVERRUNNING	CARRY	—	—
DRIVE	ON	—	ON	—	LOCK / OVERRUNNING	LOCK / OVERRUNNING	1.0 / 1.6 / 2.67	4.2 / — / 3.8
GRADE RETARDER CLUTCH	—	—	—	ON	OVERRUNNING	CARRY	2.67	2.67

Fig. 3—Turboglide arrangement—grade retarder.



RANGE	NEUTRAL	REVERSE	FORWARD	GRADE RETARDER CLUTCH	T_1 OVERRUNNING CLUTCH	T_2 OVERRUNNING CLUTCH	GEAR RATIO	OVERALL RATIO
PARK	—	—	—	—	OVERRUNNING	CARRY	—	—
REVERSE	ON	ON	—	—	LOCK	CARRY	1.78	3.1
NEUTRAL	—	—	—	—	OVERRUNNING	CARRY	—	—
DRIVE	ON	—	ON	—	LOCK / OVERRUNNING	LOCK / OVERRUNNING	1.0 / 1.6 / 2.67	4.2 / — / 3.8
GRADE RETARDER CLUTCH	—	—	—	ON	OVERRUNNING	CARRY	2.67	2.67

Fig. 4—Turboglide arrangement—reverse.

moment or torques should be as shown so that the sum of the turbine torques are equal to the sum of the engine and stator torques.

The family of torque curves is arranged to illustrate the direction as well as the relative magnitudes. For maximum output at stall, the total available torque (engine plus stator) should be arranged to react against the first turbine (the largest gear multiplication). Thus, at stall, T_2 and T_3 torque must equal zero. The engine speed curve is primarily a pump function and is based on a selected stall speed and N/V factor. The curve characteristics between stall and maximum vehicle speed are established by the efficiency factor so that the engine speed curve may be roughed-in prior to establishing blade angles and gear ratios. It now may be seen that with the first turbine running at 2.67 times the output rpm that its useful range is limited by its proximity to engine speed. The limit or freewheel point may be more or less than engine speed depending on the final selection of blade angles. At the speed shown, the second turbine should carry as much of the available torque as possible. However since T_3 must start at stall, the available torque at speed X must be split between T_2 and T_3 with T_2 carrying the largest possible share. With the second turbine running at 1.6 times output, its useful range is limited to speed Y. At this speed, T_3 torque must equal engine plus the stator and ultimately engine torque at the freewheel point of the stator. Thus the total output torque at any speed is obviously equal to 2.67 times T_1 plus 1.6 times T_2, plus T_3 torque.

This torque distribution is optimum, and cannot be improved on by subsequent blade design.

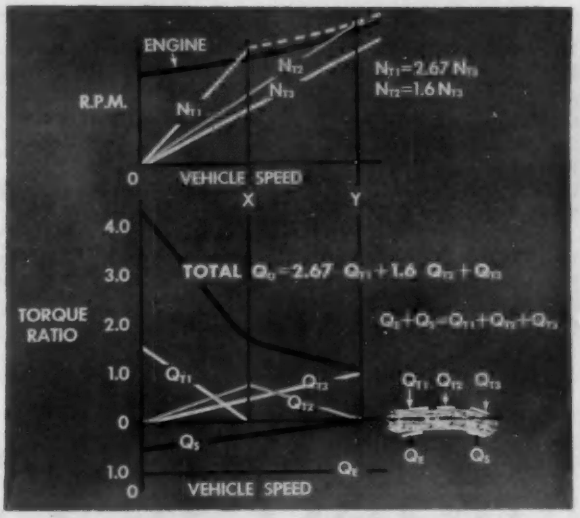


Fig. 5—Optimum wide-open-throttle performance.

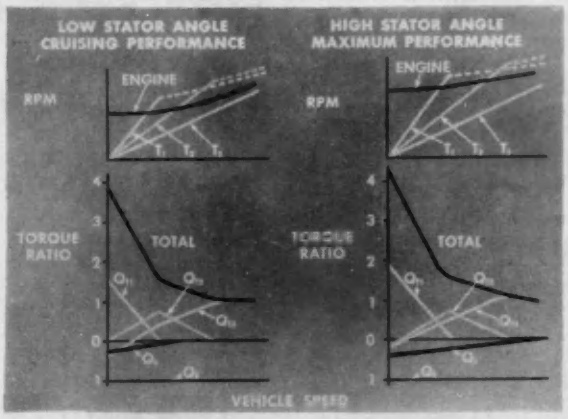


Fig. 6—Turboglide torque distribution.

Turboglide Distribution

Turboglide blade development has resulted in the distribution shown in Fig. 6.

The selection of a stator angle producing a high stall speed results in maximum output as a consequence of high input horsepower as well as high torque ratio. However, as with all highly regenerative stators, cruising efficiency is down and part throttle starts have a characteristic loose feeling.

The dual blade angle eliminates these deficiencies by providing a low angle for tight connected operation for normal driving while allowing high angle for maximum performance. Individual and total torque ratio for high and low angle are shown.

Fig. 7 is the product of the above distribution and represents the actual wide-open-throttle performance of the Turboglide with a Chevrolet 283 cu in., 4-barrel-carburetor engine.

The Turboglide allows simultaneous modulation of both engine and transmission performance. For example, by depression of the throttle alone any performance value is available from road-load, to wide-open throttle low angle. Further depression of the throttle results in the blade change and maximum performance.

Control System

Due to the absence of shifts, the control system is relatively simple. It contains the conventional input and output crescent pumps, a main regulator valve providing the necessary pressure for holding

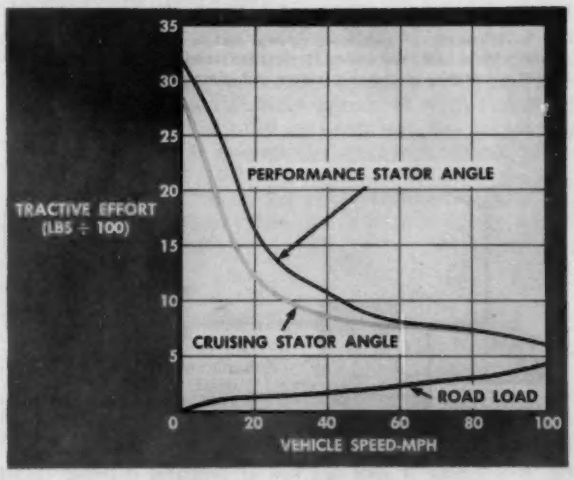


Fig. 7—Turboglide tractive effort.

the various clutches and allowing the rear pump to bypass the front for a reduction in parasitic losses. Also in the interest of minimum losses, a vacuum modulator system varies the regulated pressure in proportion to engine torque so that normal cruising is at minimum pressure (90 psi). A manually operated selector valve routes oil pressure to the required clutches.

A detent or stator valve is spring loaded against the throttle linkage so that, on depression, oil is exhausted on the forward side of the stator pistons allowing converter pressure to force the piston to the high blade angle position. An accumulator and fixed orifice provide the necessary cushioning of the "garage" shifts. Converter cooling and charging pressure are ported through the main regulator valve with an exhaust restriction to limit the maximum flow. The cooler return is routed to the lubricating passages containing a pressure-limiting valve. A time delay accumulator prevents a sudden drop in line pressure on quick release of the throttle.

(Paper, "The Chevrolet Turboglide Transmission," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

J-47 Turbojet Engine . . .

. . . employs G.E. integrated electronic control to obtain needed accuracies and coordination of functions.

Based on paper by **R. E. Ledbetter,** General Electric Co.

THE control for the J-47 turbojet engine is primarily an electronic device that meters fuel flow under acceleration conditions according to compressor discharge pressure and compressor inlet temperature.

A simplified schematic of the control system is shown in Fig. 1. The inputs are (from left to right): pilot signal, inlet temperature, rpm, compressor discharge pressure, exhaust temperature, and jet nozzle position feedback. The outputs are main engine fuel flow, afterburner fuel flow, and jet nozzle area.

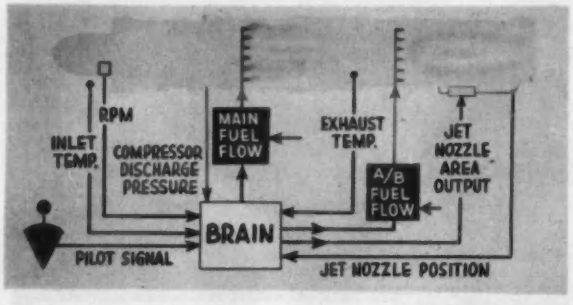


Fig. 1—Schematic of electronic control system used on J-47 turbojet engine. Main fuel flow under acceleration conditions is set as a function of compressor discharge pressure and compressor inlet temperature.

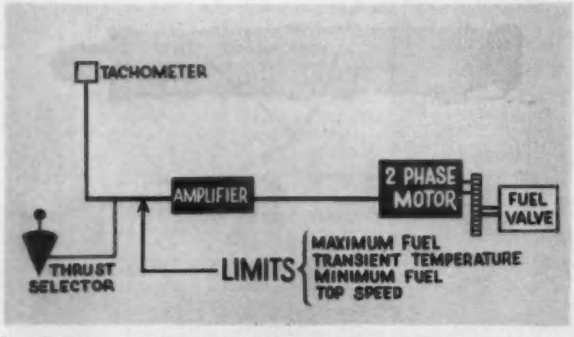


Fig. 2—Schematic of main fuel flow of integrated electronic control system.

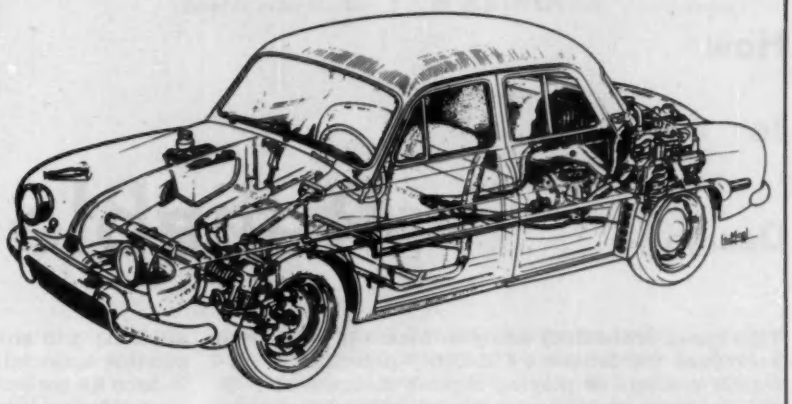
After evaluation, the electronic approach was decided upon as offering the best mechanization for a truly integrated control with the accuracies needed and the coordinated functions to be performed. It offers a minimum effect of fuel contamination, compared with computers using engine fuel flow as working media, and it offers no problem at −65 F, compared to computers using hydraulic oil as the working fluid. Approaches such as magnetic amplifiers and pneumatics involved too many unknowns at the time design had to be committed.

A schematic of the main fuel control is shown in Fig. 2. Main fuel flow is metered to the engine by a flow setting bypass-type fuel valve shown at the right. This valve is positioned by a 2-phase a-c motor and feedback position signal and sets fuel flow as a function of valve position. The thrust selector rpm signal is compared with the signal from the engine-driven tachometer, and the amplifier causes the fuel valve to move accordingly, except for certain imposed limits including transient exhaust temperature limit, maximum fuel schedule as a function of compressor discharge pressure and compressor inlet temperature, minimum fuel as a function of CDP and maximum rpm.

Similar subsystems were designed for reheat fuel control and nozzle control. The exhaust temperature sensor used is a special fast response loop-type, chromel-alumel, thermocouple, designed especially for this system. The afterburner fuel control valve is of the throttling type, designed to match the characteristics of the turbine-driven, centrifugal-type, afterburner fuel pump. The jet nozzle actuator consists of a d-c motor driving a ball bearing screw jack through suitable gearing. The motor is controlled from the amplifier with power supplied by the engine driven tach-amplidyne combination. The jet nozzle actuator can also be jogged by the pilot with aircraft d-c power in an emergency. The compressor discharge sensor is a rugged bellows-potentiometer arrangement, supplying a voltage ratio to the amplifier.

(This abridgment was based on paper, "Jet Engine Control." It is available from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Renault's rear-engined DAUPHINE: In design of this car, Renault faced all the major problems inherent in putting an engine in the rear of a passenger car. This article discusses briefly how each of the problems was resolved. (This article is based on paper "Rear-Engine Motor Cars—European Point of View.")



Rear-Engine Car Design

Based on paper by **Fernand Picard,** Regie Nationale des Usines Renault

IN designing its 5-hp, 1000-kg Dauphine, Renault made decisions on how to face six major difficulties inherent in placing a powerplant in the rear of a passenger automobile.

It faced the weight distribution problem by managing a ratio of weight on front wheels to total weight which remains between 40 and 42% with any loading . . . as compared with variation between 45 and 50% with conventional design, and between 48 and 50% with front-wheel drive.

It solved the problem of getting a proper circulation for cooling across the radiator fins by:

- Working on the ensemble of the radiator and fan.
- Directing the airflow in front and in back of the radiator in such a manner as not to waste such dynamic pressure as is present.

The Dauphine fan, for example was made somewhat larger than that of a comparable front-engined car. Once solved for maximum road speed, this solution of the problem was found satisfactory for the lower gears and in the mountains because the system, which has available but a small dynamic pressure, is practically independent. The car will, therefore, operate at a temperature which is practically constant under these different conditions. The front-engined car, on the other hand, will cool too much on the level (in third or fourth gear) and overheat when running in the lower gears in the mountains.

To defrost the windshield and keep passengers warm, the fairly long conduit necessary was designed with a cross-section 50% greater than normal . . . which means 25% greater diameter . . . and then this larger conduit was insulated by a coating of sponge rubber.

With this arrangement, the loss of pressure in the conduit is about 2 mm of water—and the temperature drop, with an outside temperature of 14 F and a speed of 44 mph, is but 11 F. The efficiency of the heater, therefore, is comparable to that of front-engine systems. Besides, it has the advantage of taking its air from a zone which is not contaminated by the exhaust gases of cars in front of it.

How to find ways of reducing the complication and cost of the long control rods or cables, necessary to operate the throttle, starter, clutch, and gearbox, was one of the more difficult problems met by Dauphine designers.

The perfection of modern cable and conduit controls solved most of the problems by permitting these rods and cables to take the most tortuous paths—especially those for the clutch and throttle pedals. Use of a floor-mounted gearshift made this control easy to design. . . . And development of automatic chokes and solenoid-operated starters has eliminated the distant controls from these accessories. An electro-magnetically operated clutch resolves the problem of clutch control.

The difficulty of making the same basic mechanical structure apply to sedans, panel trucks, and station wagons is particularly apparent with the rear-engine design. The only real solution lies in getting daily output high enough to permit the manufacturer to drop the all-purpose chassis idea.

Dauphine designers did not hesitate to lengthen the front hood to provide maximum baggage space. The baggage limitations can be further alleviated by a roof rack.

Rear-Engines for Small Cars

The rear-engine design, which has now found equilibrium in both design and manufacture, is particularly adaptable to economy cars, development of which never ceases in Europe. For piston displacements of less than 1500 cc, the rear-engined car will not only maintain its present position, but will improve it.

How to Design . . . . . Reliable Aircraft

THE use of probability analyses makes it possible to compare the inherent reliability potential of hydraulic systems employing similar components. It will also show what the component reliabilities must be to meet an overall system reliability goal.

The first step is to establish the overall reliability goal, then it becomes possible to set goals for the individual systems. For example, the allowable loss rate for failure of a hydraulic powered flight control system of an 8-engine military airplane might be on the order of one per 500,000 hr.

Failures, including malfunctions, are the crux of the reliability problem. Certain degrees of failure, and resulting reduction in system performance, can, however, be tolerated before the result becomes significant; and these must be established as soon as possible upon initiation of a reliability study. This is done by consultation with engineering groups responsible for determining the type of design used to meet the performance requirements.

An example of the type of criteria which might be established is given in Table 1.

Table 1—Type of Criteria that Might Be Established

	Degree of Significant Failures	
Subsystem	Mission Abort	Loss of Airplane
Lateral control (ailerons, flaperons, spoilers, etc.)	Loss of 75% control power[a]	Loss of more than 75% control power[a]
Longitudinal control (horizontal stabilizer, elevator)	Would not abort due to partial power loss	Loss of more than 75% rate or any torque capability
Directional control (rudder)	Loss of more than 75% control power[a]	Consider that complete failure would not cause loss of airplane

[a] Remaining 25% control power could be a combination of 50% rate and 50% deflection capability.

Elements of Hydraulic System Reliability

Once the reliability goals have been established and the degrees of significant failure defined, it is possible to predict mathematically the probability of significant failures with various system arrangements and compare the resulting reliabilities with the established goal. Component arrangement and connection have a very important bearing on the reliability of the overall system. A flight control hydraulic system such as considered in our example is made up of subsystems arranged in parallel with components in each subsystem arranged both in series and parallel circuits.

Series arrangement of parts arranged chain fashion (as shown in Fig. 1) are dependent upon each other as links in a chain. Failure of one component or link is equivalent to failure of the entire subsystem. This relationship can be expressed mathematically as

$$P = p_1 \times p_2 \times p_3 \ldots \times p_n$$

where:

P = Probability of the system survival

p_1, p_2, p_3, p_n = Probabilities of survival of individual components

or:

$$P = p^n$$

where the probabilities for all parts are approximately the same

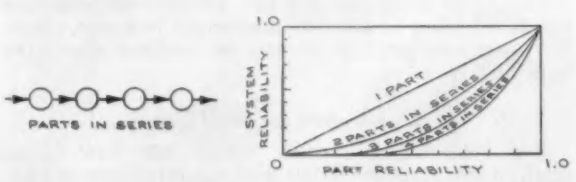


Fig. 1—Series arrangement of parts makes components dependent on each other. Failure of one component means failure of the entire subsystem.

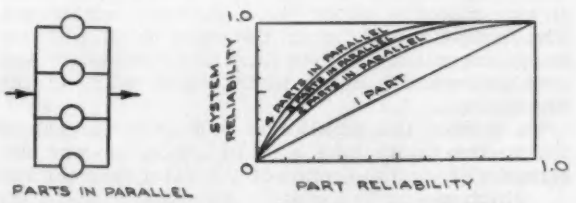


Fig. 2—Parallel arrangement of components gives an overall reliability higher than that of the components.

Based on paper by **E. T. Raymond,** Boeing Airplane Co.

Hydraulic Systems

This is an exponential function and can be as shown graphically. A system that contains a large number of components arranged in series with each dependent upon the other in sequence must have very high individual component survival probabilities if high overall reliability is desired. By reducing the number of components in series, it is possible to achieve an equivalent overall reliability using components that have lower individual survival probabilities. This method is important to the designer when he desires to utilize components which are known to have high failure rates.

Parallel connection of components (as shown in Fig. 2) is a common arrangement where it is desired that the overall reliability be higher than that of the components. This is probably the most widely used method for improving reliability. For example, it is commonly accepted that 4-engined airplanes have greater reliability (and safety) than single-engined planes. A system of parallel components will not completely fail unless all components fail. The unreliability of a parallel system is a product of the part unreliabilities and its reliability probability is:

$$P = 1 - (1 - p)^n$$

where:

p = Reliability probability of an individual component

$1 - p$ = Unreliability probability of an individual component

n = Number of components

Parallel connection arrangement of parts or components generally does require more components. This can be viewed as the price paid for greater reliability; however, in many cases theoretical reliability gains are not always achieved due to the increase in maintenance required.

In the reliability studies presented herein the items in the reliability chain have been shortened to include only the following components:

Jet engine
Hydraulic pump
Leakage
Linear actuator

Jet engine
Hydraulic pump
Leakage
Hydraulic motor
Pressure-operated brake

For these studies the leakage from all components is considered as lumped into one factor. In the case of the power control valves, manually operated, cable controlled valves were considered as having such a high degree of reliability that their probable failure rate would not be a significant factor in the mathematical analysis. All mechanisms were considered to have a similar high degree of reliability. However, in the system utilizing hydraulic motors the pressure-operated brakes, used to prevent reversing of a ball screw or differential gearing, are included.

Selection of Various Arrangements

In the reliability analysis of a hydraulic powered flight control system for an 8-engined military airplane, it was assumed that if a system could be arranged to meet the required goals concerning airplane loss, any reasonable abort goals would be adequately covered. This assumption was later borne out in analysis of the acceptable systems.

It was also assumed that a minimum of two actuating cylinders per wing for lateral control and two actuating cylinders or two or more hydraulic motors for pitch control would be required. In the first arrangements studied, designated systems A and A-1 (as shown in diagrammatic form in Fig. 3), the subsystems were kept as simple and direct as possible with each dependent only on a single engine, pump, and actuator. When it was found that predicted overall reliability fell far short of the required goal, the effect of adding a standby pump and third hydraulic motor to the stabilizer control system was investigated. This arrangement, designated system B, was also found to have too great a failure probability.

Because of the need for obtaining considerably higher reliability than inherent in systems A, A-1, and B, it was evident that either existing components be backed up by others grouped in parallel or that other parallel subsystems be added. System C, a triple system, and systems D and D-1, dual systems (Fig. 4), employ both concepts and are found to be capable of meeting the established reliability goal provided adequately low leakage rates are obtained. Note that all systems were confined strictly to actuating flight controls with no other services attached.

These are typical of the variations in system arrangement which can be employed. It is interesting to note that all of the systems shown contain nearly an equal number of components; and estimated weights compare so closely that the difference between the heaviest and lightest is within approximately 20%. As will be seen in the following section,

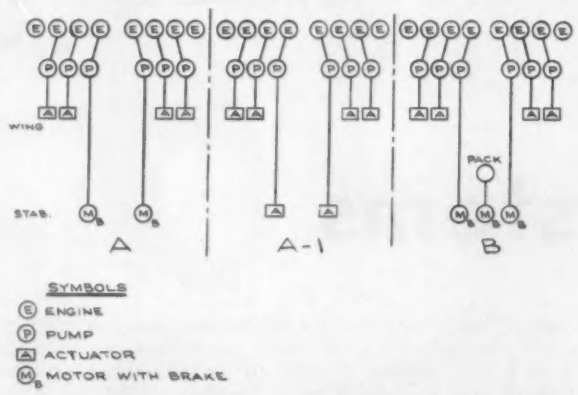


Fig. 3—Systems A and A-1 with simple and direct subsystems each dependent only on a single engine, pump, and actuator. System B has an added standby pump and third hydraulic motor.

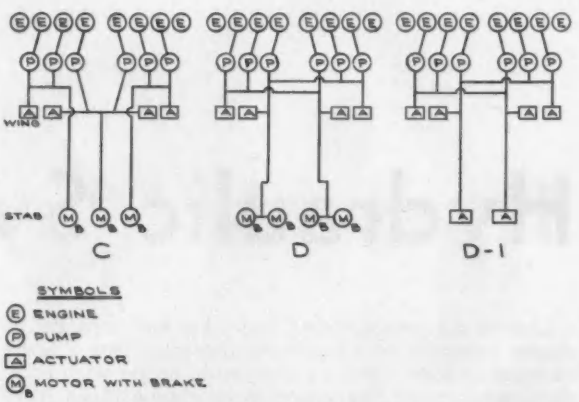


Fig. 4—System C, a triple system, and D and D-1, dual systems, are similar to those shown in Fig. 3, but backing up existing components with others grouped in parallel and adding other parallel subsystems has given them greater reliability.

the range of predicted reliabilities is considerably greater.

Reliability Predictions

As discussed previously, an overall system reliability prediction can be made mathematically by probability analysis for each system arrangement selected. In each case the systems are made up of individual components most of which have been used in similar form in previous systems and with which we have experience upon which to base a prediction of individual reliability. Because of the exponential type of calculations involved in determining overall system reliability, small errors in the initial assumptions can lead to large errors in the calculated result. For this reason it is felt that absolute reliability cannot be accurately forecast. However, reliability studies can be a valuable tool by which to obtain a *comparison* of various system arrangements if calculations are made over a sufficiently wide range of assumptions. An example of the method by which this can be done is seen in the probability equation for calculating reliability of system D-1.

Overall reliability of system D-1 = $(R^6 + 6R^5Q_R + 15R^4Q_R{}^2 + 18R^3Q_R{}^3 + 9R^2Q_R{}^4)\ [L^2(1-Q_A{}^4)\ (1-Q_S{}^2) + 2LQ_L(1-Q_A{}^2)S] + (2R^3Q_R{}^3 + 6R^2Q_R{}^4)\ [LS(1-Q_A{}^2)]$

where:

R = Engine reliability times pump reliability
E = Engine reliability
P = Pump reliability
A = Reliability of actuator (lateral control)
S = Reliability of actuator (stabilizer)
L = Probability of leakage in any one circuit
Q = Unreliability = 1 – reliability; example: $Q_R = 1 - R$

Solution by ordinary methods can be exceedingly tedious if several values must be considered for each

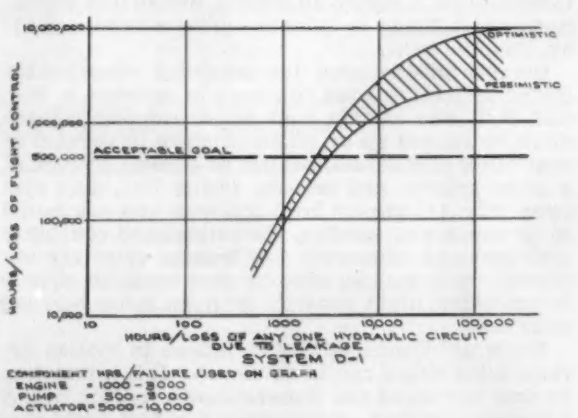


Fig. 5—Overall system reliability is plotted against the probability of suffering fluid leakage.

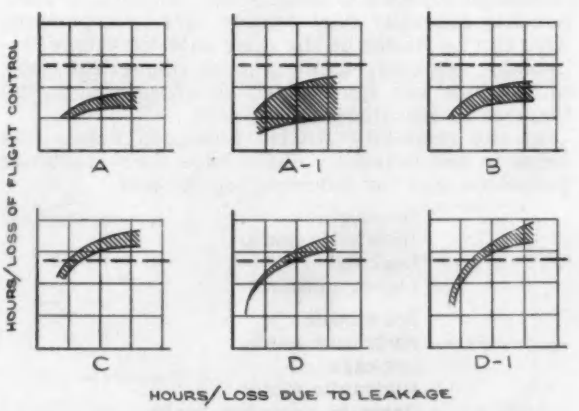


Fig. 6—Comparative reliability of systems studied.

variable. This is especially true since it is necessary to carry most figures to the eighth place. However, it is possible to set up the equation for digital computer solution and by use of a computer such as the IBM model 701 obtain solutions for an infinitely wide range of values for each variable. Results then presented in the form of curves (Figs. 5 and 6) clearly show the comparative reliability of the systems studied and enable the observer to determine if it is possible for the established goals to be met.

In the examples shown, overall system reliability is plotted against the probability of suffering fluid leakage; and for each system a curve is presented for a series of optimistic and a series of pessimistic component reliability assumptions. Based upon previous experience supported by a certain amount of statistical data it is felt that a reasonable range of assumptions can be made for most significant components such as engines, electric motors, turbines, pumps, actuators, and hydraulic motors.

In selecting an optimum system, it is recommended that the designer not choose merely the one indicating the highest reliability. The range of reliability resulting from component assumptions must also be considered. In several of the systems investigated the resulting range is much narrower than in others, indicating less sensitivity to changes in component reliability than in the systems where the overall band is large. Also, the leakage reliability which must be obtained in order to reach the level where leakage is no longer a factor must be taken into account, since it may be highly unlikely that it can be obtained. In any event, the reliability factor must be weighted in its proper perspective against the other design factors which must be considered in order that the system, and airplane design, is not unduly compromised.

(Paper, "The Use of Reliability Analysis in the Design of Aircraft Hydraulic Systems," on which this abridgment is based, was presented at a meeting of the SAE Hydraulic Committee A-6 at Los Angeles, Calif.)

Management Controls . . .

. . . don't work automatically. It's their use as a basis for action that makes them effective.

Based on secretary's report by **D. H. Davis,** A. O. Smith Corp.

IF controls are conceived intelligently to express the objectives and policies of management, then used as a basis for action, business efficiency can be greatly improved.

Control reports must be made available to management with the greatest possible speed to show promptly the areas needing attention. Then corrective action should follow without delay.

The following six considerations can help in the formulation of a control system or in the assessment of one already established:

1. Are controls based on a profit motive concept? The ideal control device is one which motivates, that is, invites and encourages action toward profit improvement.

2. Does the control system provide objectives for all? The system should be tailored to function at all levels of the organization, with no area of effort overlooked.

3. Are controls provided on a vertical or horizontal basis? Control devices should parallel or coincide with assigned responsibilities, therefore they should avoid a shotgun approach to an area where responsibility is pinpointed.

4. Do reports contain the minimum of information, with every item reported being one which the person receiving the report can do something about? Reports should be simple, few in number, and readily understood by each manager.

5. Does the system provide broad measuring-stick control for top management? Many factors may be included, yet provide a means for recognizing changes in the business trend.

6. Does the control system provide appropriate meetings for review of results and trends?

Budgets are perhaps the most widely accepted tool of management control, but they are no better than the quality of the planning they represent. Too frequently, budgets are established on the basis of past experience, without due consideration of new factors.

There are three points to observe in the use of budgets:

1. Don't use budgets as a pressure device or whip. Use them as a means for localizing areas needing corrective action. A budget is a device to help management assist the next lower echelon.

2. Use a budget to impress all supervisors of their participation in management. A department foreman may have large sums of money, in effect, passing through his hands. The budget can highlight this fact to impress upon a supervisor that he is a manager.

3. Don't overlook areas where actual performance exceeds budgeted performance. Commendation may be due, but also, superior performance may be attained at the expense of some other factor.

Control must never be allowed to become dull routine. To be effective, techniques should stir the imagination and challenge abilities. Keep on the alert for new techniques or variations on the old to prevent going stale.

(This article was based on the secretary's report of the panel on Management Controls. Panel leader was E. J. Leewe, A. O. Smith Corp.; secretary was D. H. Davis, A. O. Smith Corp. Panel members were: W. L. Cleveland, Bucyrus-Erie Co.; J. D. Gray, Booz, Allen, & Hamilton; A. Hall, Nordberg Mfg. Co; F. O. Kovich, A. P. Controls Corp. This report, together with 7 other panel reports, is available as SP-316 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

6-Year Use in Buses Leads CTA to say that

LPG Lives Up to the

GENERALLY speaking, LPG has lived up to the predictions that were made for it six years ago at the beginning of its use in Chicago Transit Authority buses.

After six years, CTA is convinced of some 19 realizable advantages for such fuel in its bus operations. It has learned, also, an almost similar number of specific things a user must make certain about—if he is to utilize LPG successfully and safely. The advantages are there, but so are the requirements. To get the advantages, the requirements must be met.

CTA has found in 168,900,000 miles of operating experience, the following facts about LPG as compared with other fuels in its bus operations:

1. . . . In its last bid for motor buses—as in previous bids since 1950—CTA made a saving in cost of about $2200 on each LPG-powered bus.

This saving is essentially the difference between the initial engine cost between a diesel and a propane-powered unit. (CTA bus specs are spelled out in detail.) So, the difference in the competitive bids . . . which must comply with the same quality and workmanship requirements . . . is essentially the difference in cost of the powerplant.

2. . . . Propane-powered units have accumulated 200,000 miles per unit without an engine-rebuild . . . nor does fuel and oil mileage yet warrant a re-ring program.

Bus engines using other types of fuel in CTA operation require re-ringing at 160,000 miles.

3. . . . CTA gets more power per pound of fuel on the same size engine with propane.

This result accrues from being able to use higher compression ratios and advanced ignition because of the higher octane rating of propane fuels (approximately 125 on straight propane).

4. . . . LPG powerplants, by actual test, are much quieter.

No blowers or superchargers with accompanying whine are needed for satisfactory performance. Compression pressures, valve arrangement, and operation on diesels are such that exhaust noises are much higher.

5. . . . LPG fuel burns clean and carbon formation on engine parts is very light.

Even on engines overhauled after 200,000 miles, piston rings were very free and carbon formation on rings and ring grooves was very slight.

6. . . . Cylinder walls on LPG engines remain well lubricated. This is shown by the slight piston and wall wear and good piston ring condition of engines overhauled after 200,000 miles.

Cylinder wall lubrication is not washed down in LPG-powered engines because the LPG is already a gas when it enters the engine manifold and combustion chambers.

7. . . . No crankcase sludging occurs in LPG-powered engines.

This results from a combination of reduced carbon formation, limited fuel dilution, and limited depositing of carbon or other contaminants—due to the slight cylinder-wall wear.

8. . . . LPG does not gum.

It does not gum because it is a gas from the time it leaves the vaporizer - regulator. Therefore, there is no drop-out of hydrocarbons or varnish to coat the carburetor manifold and other engine parts. The propane fuel system is "sealed," and, even with protracted storage, the fuel doesn't oxidize.

9. . . . Oil consumption is reduced.

Oil consumption is lower in propane-fueled engines because the engine parts stay relatively carbon-free . . . and, the rings remaining clean, cylinder-wall, piston, and ring wear is reduced.

10. . . . CTA's propane-fueled engine drain period is 16,000 miles; for diesels 6,000 miles.

Reasons are much the same as in (9). The basis for CTA crankcase oil change is generally the amount of soot, water, metallic particles present—and the acid content of the oil.

11. . . . Carburetor life is improved in LPG engines.

LPG carburetors have fewer parts and use jets with larger openings. So, they will oper-

Predictions Made for It

Based on paper by **Stanley D. Forsythe,** Chicago Transit Authority

ate approximately 72,000 miles between rebuilds; gasoline carburetors about 30,000 miles. BUT, maintenance cost of LPG vaporizer-regulators is somewhat higher than that of a gasoline fuel pump. This was the weakest link in the original LPG automotive components, but later designs have been improved. Maintenance costs are decreasing.

12. . . . **Spark plug life is longer in LPG engines.** Spark plug life of propane-fueled engines runs from 24,000 to 32,000 miles; for gasoline-fueled engines from 8,000 to 12,000 miles. Reason: greatly reduced carbon deposits with propane.

13. . . . **Muffler life is considerably longer.** Due to absence of lead additives and the cleaner burning of LPG fuel, mufflers do not become clogged.

14. . . . **Maintenance cost is less on LPG engines.** CTA records to date point clearly to this conclusion, but actual dollar values cannot yet be established.

15. . . . **LPG engines accelerate faster and perform better than engines of the same size using other fuels.** This results from the increased compression ratio and more advanced spark possible with LPG-fueled units.

16. . . . **LPG buses operating on CTA property are exhaust-smoke and exhaust-odor-free.** This condition exists on units which have been in operation continuously for the past six years without a re-ring or an engine rebuild.

17. . . . **In fueling, the tank cannot be overfilled nor can the pressure within the tank become excessive.** This results from use of the Parkhill tank and automatic filler nozzle. The hostler connects the filler to the vehicle fuel tank, locks the handle, and turns on the pump. The tank is filled to rejection . . . and the necessary expansion space is automatically provided by an internal ullage tank, which is

"And the Greatest of These Is Safety . . ."

In six years and nearly 169,000,000 miles of experience with LPG-propelled buses, Chicago Transit authority has learned a great many things about LPG advantages . . . and the requirements for its successful use.

This article tells the facts—on both fronts. Written by CTA's general superintendent of engineering, it speaks directly to automotive engineers.

On the all-important question of SAFETY, Author Forsythe reports:

"This operation over the past six years has been accomplished without any property damage or personal injury. There have been a few small fires in the engine compartments of the buses, but the fire loss per mile of operation due to all causes is lower with LPG than with two other standard fuels.

"This record results from an operation which involves:

- **A fleet of LPG-using buses which now numbers 1050, with daily deliveries being made on 250 more already ordered.**
- **Double handling of 69,000,000 gal of LPG at six different locations;**
- **Use of a storage capacity of 225,000 gal, contained in 18,000 gal water-capacity tanks . . . two, three, or four at each of six locations;**
- **Engineering of safety into each of these installations at the start.**

"We expect to maintain this safety record indefinitely by continuing periodic inspection of mechanical components and operating practices."

blocked off from the main fuel tank during filling. It is a "sealed" system.

18. . . . No moisture gets in to the LPG-fueled system.

The LPG is under pressure at all times—from the refiner to the vehicle storage tank to the engine manifold. The "sealed" system is not affected by moisture arising from temperature changes. For the same reason, there need be no concern about evaporation of the light ends because the sealed system has no vents.

19. . . . Drivers like the LPG-powered buses.

Drivers like them because, they say, "this is like an electric-operated vehicle as far as exhaust odors and fumes are concerned."

Requirements for LPG Operation

To get the best from LPG-fueled vehicles, it is necessary to use the higher compression ratios which the higher octane rating of LPG permits. So, the engine designer has to take that into account in designing his bearing areas, connecting rods, wrist-pin sizes, pistons, and so forth.

Carburetors and carburetor valves used with LPG should be rugged . . . and the valves should provide positive control. Vaporizer coils (if used) should be soldered and have UL approval. Manifolds should be of the "cold" type—to maintain volumetric efficiency.

LPG ignition temperatures are higher. So, ignition systems must be kept in good condition. Hotter combustion temperatures mean that spark plugs should be in the "colder" range group. The distributor advance curve should be of the type designed for LPG operation.

The fuel tank should be of the automatic-fill type . . . with a built-in expansion tank built according to the 1949 or earlier ASME U69 Code. (This code permits 125% over working pressure (312 lb) setting of the relief valve.) Fuel lines should be of 18.8 stainless steel; connector fittings of the heavy-duty type.

As a safety device, CTA recommends a good quality spring-closed solenoid-opened fuel line shutoff valve, connected immediately down-stream of the fuel line filter.

Fuel should be purchased under NGAA specifications, so as to limit contaminants and high working pressures. If operation is in areas where high working pressures are encountered, a mixture of propane-butane may be used to lower fuel pressures and to permit faster fueling. CTA fuel-pumping rate is about 30 gpm.

Propane Can Be Safe

If the equipment is properly installed and the fuel handling practices comply with the requirements and safety codes as set up by the National Board of Fire Underwriters, CTA feels that propane is as safe or safer than other engine fuels.

The equipment installed, such as tanks, protective devices, and pumps in the storage area . . . and regulators, filters, shutoff valves, fittings, and other units on the vehicle . . . should be of high quality. Moreover, they should meet with UL approval and should comply with NBFU recommendations.

Safety is engineered into the LPG storage tank by virtue of its high pressure design and thick shell. (This is necessary to maintain the fuel under pressure.) There is much less likelihood of rupturing a propane tank in a collision or other type of accident than there would be with conventional fuel tanks.

(Paper, "169,000,000 Bus Miles in Chicago with LPG," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers).

Production Panel Nuggets

■ *Three suggestions to help control perishable tools are made by* Carl Rasmussen:

1. Store broken tools in boxes bearing department number, and place in the shop;

2. Police jigs and fixtures going back to the tool crib. Inspect worn bushings and similar parts closely;

3. Analyze grinding and sharpening practices.

■ *"Free up your creative people from routines and procedures so that they can use their imaginations and creative minds."*

(R. A. Dimberg *listed this as a most significant fact developed at a Production Forum panel on Cost Reduction Programs.*)

■ *International Harvester Co. has a full-time departmental section of its engineering department which works with engineering on cost reduction of product.*

—Roger Hubbel

Tilt-Wing VTOL Aircraft . . .

. . . holds out promise of giving both helicopter and fixed-wing aircraft real competition under certain conditions.

Based on paper by **F. R. Mazzitelli,** Vertol Aircraft Corp.

ON a cost per seat basis the tilt-wing VTOL aircraft appears to fall midway between the helicopter and the fixed-wing airplane, but in the lower block ranges (under 50 miles) the VTOL should be less expensive than the helicopter. If a realistic charge of $2.00 per seat limousine fare is added to the direct operating cost of the fixed-wing airplane, the VTOL becomes definitely competitive with the airplane up to a 250-mile block distance.

These conclusions, shown graphically in Fig. 1, are based on estimated operating costs for a tilt-wing VTOL, a tandem transport helicopter, and an airplane essentially of the DC-3 type and built at today's cost. Each vehicle is capable of carrying 24 passengers, or a 6000-lb payload.

A somewhat different picture is presented if the standard for comparison is an existing DC-3 with added limousine fare of $2.00. In this case, the VTOL is competitive with it up to 100 miles, while the helicopter would be competitive up to 70 miles.

VTOL Wins on Block Time

A block-time comparison of these three types of aircraft (Fig. 1) shows the helicopter taking less time than the fixed-wing up to 90 miles, due to a higher block speed in the low block range. In the higher block distances the fixed-wing is superior. Here again, to be realistic, an increment of time should be added to cover the time required to reach the airport. And the greater that time increment, the more competitive the helicopter becomes.

The VTOL would take appreciably less time throughout the entire range. This is to be expected because the VTOL must have much more power than a fixed-wing in order to take-off and land vertically. This gives it a higher cruising speed. We can conclude, therefore, that the VTOL, particularly the tilt-wing VTOL, is competitive with the fixed-wing aircraft, but since we are still on the "learning" curve for this type of aircraft, its initial cost is approximately twice that of a competitive helicopter or fixed-wing airplane. Moreover, of course, the tilt-wing VTOL has yet to be built and proved satisfactory.

This abridgment was based on paper, "The Tilt-Wing VTOL Aircraft as a Commercial Air Transport." It is available from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

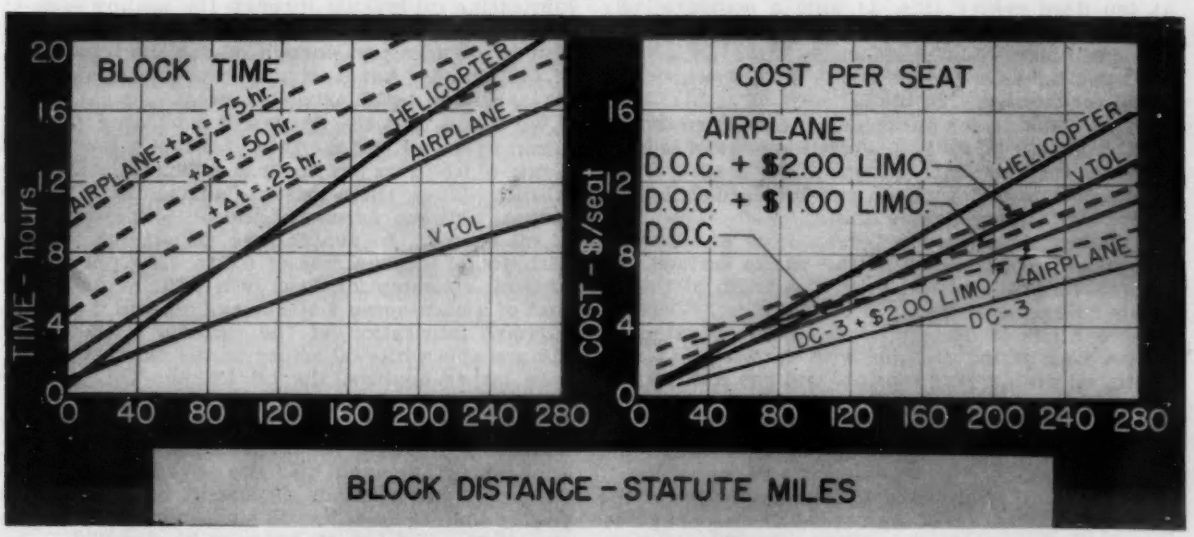


Fig. 1—Block time and cost per seat comparisons of a tilt-wing VTOL, a tandem transport helicopter, and a fixed-wing airplane of the DC-3 type.

Licking Some Design Problems of a Loop-Scavenged

THREE of the problems that we had to solve in designing the loop-scavenged 2-stroke diesel engine were:

1. To obtain a sufficient, but not excessive, oil supply to the cylinder walls, and to obtain reasonable oil consumption, together with minimum wear.
2. To avoid deformation of the piston by thermal and mechanical forces.
3. To avoid scuffing of the cylinder wall in the port area.

Oil Supply and Sealing Problems

The major mechanical problem with a loop-scavenged 2-stroke engine is that of obtaining a sufficient, but not excessive, oil supply to the cylinder walls, and to obtain reasonable lubricating oil consumption, together with the smallest possible cylinder wear.

Conditions here are considerably more unfavorable than in a 4-stroke engine. When the piston is at top dead center (Fig. 1) only a comparatively narrow sealing belt prevents the leakage of oil from the crankcase into the exhaust ports. Of course, high-performance engines must have a well-lubricated mechanism. In many cases oil is also used for spray cooling the under side of the piston crown. The crankcase is, thus, filled with oil-saturated air. Only by very accurate design of the sealing areas at the bottom of the piston can the oil distribution be kept within reasonable limits.

Variables affecting the performance of the sealing areas are the finish of the piston surface, the clearances of the piston skirt, the finish of the oil scraper rings, and the finish of the liners. Tests on various kinds of oil scraper rings, which extended over a long period of time, with variations in ring width, oil drains, ring tension, and the like, as well as variations in piston skirt layout, were necessary before practical solutions were found. It is now possible to control the leakage of oil through the sealing areas.

This control of oil leakage was imperative for the practical application of high-speed 2-stroke engines, especially for speeds over 2000 rpm. The oil consumption of loop-scavenged 2-stroke engines is not only a question of economy, but also of reliability in operation. In this respect, there is a difference between 4- and 2-stroke engines. The exhaust gases of a 2-stroke engine, even at full load, contain considerable amounts of oxygen from the scavenging air which passes directly into the exhaust ports. The danger thus exists that quantities of lubricating oil may ignite in the exhaust ducts. This has happened to 2-stroke engines with excessive oil consumption. It usually does not harm the engine but certainly is unpleasant.

When we began our development on high-speed 2-stroke engines such burning exhaust pipes sometimes caused us difficulties. But now, that we have mastered the problem of oil consumption, this belongs to the past. I have not heard of such a case with our engines for a long time. With small- and medium-sized engines there is, in general, no separate oil supply to the cylinder, since this would complicate the engine and make it more costly. The lubricating oil leaking through the sealing area at the bottom of the piston must, thus, be so adjusted that it provides just enough oil for the lubrication of the cylinder but so that it prevents undesirable oil leakage into the exhaust system.

We found that the danger of a burning exhaust began at an oil leakage rate of 3 to 4 g per hp-hr. A rate of 0.5 to 1 g per hp-hr is sufficient to form an oil film. Thus, there exists a sufficiently wide difference between necessary and objectionable rates of oil supply. In general, we design our engines with an oil leakage rate of 0.8 to 1.5 g per hp-hr. This oil consumption is only a trifle higher than that of a high-speed 4-stroke engine, and it ensures effective lubrication of the cylinder without any disagreeable white oil smoke in the exhaust.

In larger engines, the oil leakage through the sealing areas is made less than that necessary for the lubrication of the cylinder and the required additional amount of oil is supplied separately. Such an arrangement has the advantage that the oil supply can be made dependent on the load, so that at smaller loads less oil burns or vaporizes from the oil film and less oil needs to be supplied.

Excerpts from paper by **Hans List,** Anstalt für Verbrennungsmotoren, Graz-Austria

2-Stroke Diesel Engine

It is important that the oil be evenly distributed on the cylinder surface, and that an even lubrication of the whole piston travel be effected. A special problem is the lubrication of the upper compression ring. This ring works with extremely high surface pressure and, owing to the efficiency of the scraper rings situated below, receives the smallest amount of oil. The part of the cylinder over which the top piston rings travel is subject to the greatest wear. The oil quantity reaching the upper piston ring can be influenced by the tension of the compression rings. In order to prevent ring and piston scuffing, uniform contact between rings and cylinder wall must be ensured. Exact ring shapes, best obtained by form-turning, are necessary.

Since the most effective sealing occurs in areas which are exposed only to slight wear, the oil consumption of a loop-scavenged 2-stroke engine does not, in general, increase with continued operation. Usually, the replacement of a cylinder liner is necessitated, not by high oil consumption, but by wear in its upper part. If this is the case, the compression rings seal insufficiently and cause hard starting. A specific rate of cylinder wear is the result of a particular condition of cylinder-liner lubrication. Since purely hydrodynamic lubrication of the cylinder running surface is not possible, wear also depends on piston and cylinder material and on the quality of their finish.

It is now an established fact that the lubrication condition in the cylinder of a loop-scavenged 2-stroke engine, as obtained by the means described, results in reasonable wear figures and that the 2-stroke engine is no longer at a considerable disadvantage compared with a 4-stroke engine.

In Europe, high-speed loop-scavenged 2-stroke engines were first installed by the firm of Gräf & Stift in their buses and heavy trucks. This firm has limited production but, up to now, has the most extensive experience in Europe in the application of this type of engine to automotive purposes. Gräf & Stift report cylinder wears as shown in Fig. 2. These values were obtained under the severe operating conditions encountered in the mountainous areas of Austria and in short-distance runs. The firm of Hanomag, who use in their tractors 2-stroke diesel engines rated at 12–14 hp at 2200 rpm, have not had any complaints about excessive cylinder wear in three years of operation. Approximately 25,000 cylinders are in use in these tractors.

The experience with the test vehicles of the Ford Works, Cologne, Germany, in which engines of our design are installed, is also favorable. After 32,000 miles a cylinder wear of 0.05 mm (0.00197 in.) was measured.

We have tried to obtain comparative material on 4-stroke engines. The Austrian firm Steyr-Daimler-

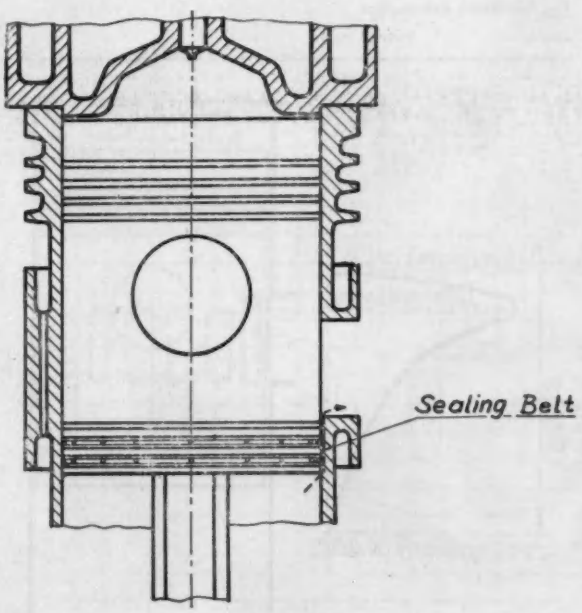


Fig. 1—Leakage path when piston is at top dead center.

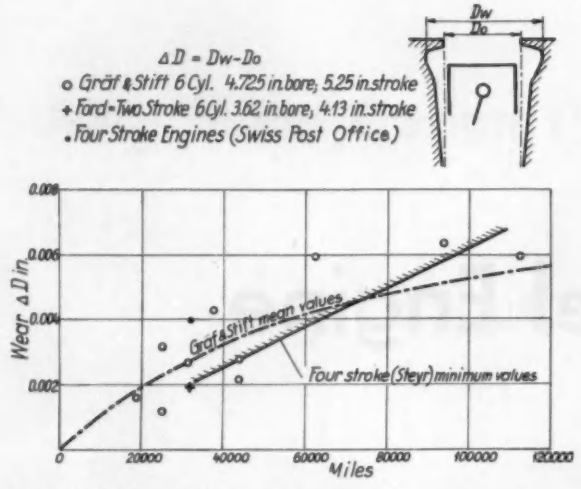


Fig. 2—Cylinder wear for two loop-scavenged engines compared with that for some 4-stroke engines.

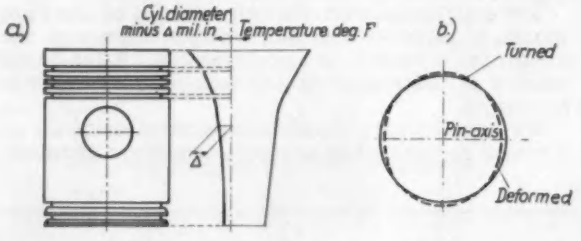


Fig. 3—Piston deformation.

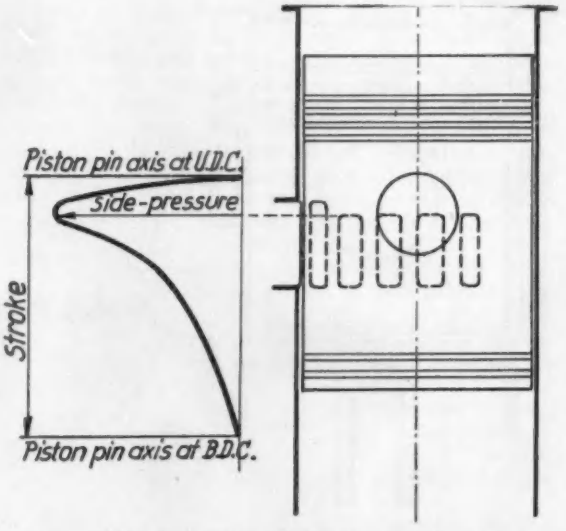


Fig. 4—Course of side pressure relative to cylinder axis.

Puch, the biggest firm in Austria producing light vans, gave us data as shown in Fig. 2.

The Swiss Post Office authorities found, after extensive tests, that their 4-stroke engines have a cylinder wear from 0.1 to 0.3 mm (0.0039 to 0.0118 in.) after 32,000 miles of service.

It follows from these results, which I have intentionally limited to such material as could be obtained from nearby sources, that the cylinder wear of high-speed, loop-scavenged 2-stroke engines compares favorably with that of 4-stroke engines.

So far, it has not been necessary to introduce special means to improve wear conditions, such as chromium-plated or hardened cylinder liners. This does not, of course, mean that such measures could not bring advantages since they would, no doubt, further increase the life of the cylinders.

Special attention has to be paid to the exact outside shape of the piston so that the side pressure to which the piston is subjected is distributed as evenly as possible over the sliding surface. A combination of crowned and oval piston skirt shape is used. In this way, the deformation of the skirt by thermal and mechanical forces is taken into account. The form of the piston skirt is considerably influenced, in the longitudinal direction (Fig. 3), by the temperature gradient. The oval contour of the piston circumference is changed by mechanical deformation. In short, the shape has to be such that, after deformation, a close and even contact of the piston surface with the cylinder is produced. The more even this contact, the better the operating conditions of the piston.

The determination of the shape of the piston, therefore, requires specific experience and tests have to be made in each individual case. We have obtained satisfactory results with simple aluminum pistons. These were, however, cast of an alloy specially developed in Europe for the purpose and which, I believe, is similar to your A-142.

Cylinder Scuffing in Port Area

Special attention must be paid to the cylinder wall in the area of the ports. The wall is interrupted by orifices which, in high-speed engines, cover a great part of the circumference, so that only comparatively small lands remain as supporting areas.

When cylinder and piston have normal proportions, the piston pin and, thus, the point of application of the side pressure, coincides with the ports at the time when the side pressure is greatest. (See Fig. 4.) The cylindrical surface area of the liner, in combination with the deformed piston, results in considerable bearing pressures which are imposed on the lands between the ports. This may lead to scuffing at these points. To prevent the possibility of scuffing, the port area is very slightly barrel-shaped. In this way these areas are freed of pressure or at least relieved and the side pressure is distributed over the uninterrupted part of the cylinder liner, with the result that maximum bearing pressures are substantially reduced.

(Paper, "High-Speed, High-Output, Loop-Scavenged 2-Stroke Diesel Engines," on which this abridgment is based is available in full, in multilith form, from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Mission effectiveness often can be increased by using . . .

Small Lightweight Turbojets

Based on paper by **Reece V. Hensley and Norman C. Witbeck**
Turbomotor Division, Curtiss-Wright Corp.

FOR missions in the high subsonic or in the supersonic range, it's very likely more efficient to use several turbojets in the 1500-lb thrust class than one big turbojet of 12,000-lb thrust.

This is the conclusion reached from performance comparison of the two hypothetical turbojets described in Table 1. The small engine has the high thrust/weight ratio normally associated with engines of this size having relatively straight-forward aerodynamic design. The large engine embodies a higher compressor pressure ratio and a thrust/weight ratio considered good for this type of engine. Representative component efficiencies, airflow characteristics, and cycle temperatures have been used. Note that equal temperatures and efficiencies have been used for both the large and small engines.

Inasmuch as the major applications of turbojet-type engines lie in the high subsonic and supersonic regimes, and these high Mach numbers generally provide near optimum airframe-engine performance at high altitudes, a valid comparison of engine potential can be based on performance of the engines in the isothermal region. Fig. 1 compares the thrust potential of the two engines under consideration in this region. The net thrust per pound of air per second is shown as a function of flight Mach number. In the high subsonic speed range the thrusts are about equal, with a slight margin of superiority for the large engine. In the supersonic speed range, the small, low pressure ratio engine provides greater thrust for each pound of air handled. This reversal is caused principally by the decreasing difference between compressor outlet temperature and turbine inlet temperature, which affects the higher pressure ratio engine more adversely than the engine having a lower pressure ratio. The thrust difference increases with Mach number, until at a Mach number of 2.4 the large engine provides only 75% of the thrust per pound of air of the small engine. The net result of the differing rates of specific thrust decrease is to increase the installed powerplant weight for the large engine installation relative to that based upon smaller engines as the flight Mach number design point increases. Data are also shown on Fig. 1 for the large engine with afterburning. At a Mach number of 2.4 the augmented thrust for this engine is about 3.7 times the unaugmented value.

The comparative efficiencies of the two engines over the Mach number range are indicated in Fig. 2,

Table 1—Basic characteristics of two typical engines, each capable of attractive performance in both subsonic and supersonic ranges

	Small Engine	Large Engine
Rated Thrust, lb	1500	12,000
Weight, lb	150	3400
Specific Weight	0.10	0.28
Compressor Pressure Ratio	7/1	12/1
Turbine Inlet Temperature, R	2100	2100
Compressor Efficiency	0.85	0.85
Turbine Efficiency	0.87	0.87

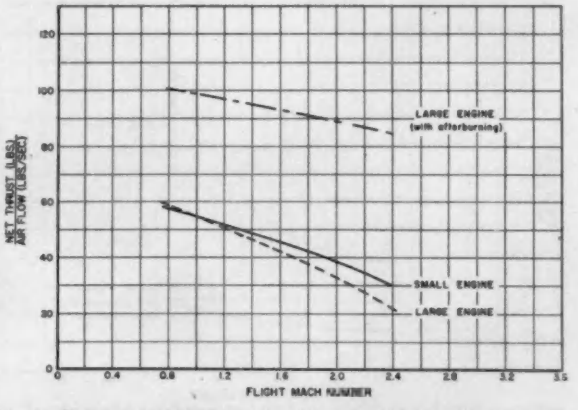


Fig. 1—Thrust potential of small and large engines is about equal in high subsonic speed range. In supersonic range, small engine has greater thrust per pound of air handled.

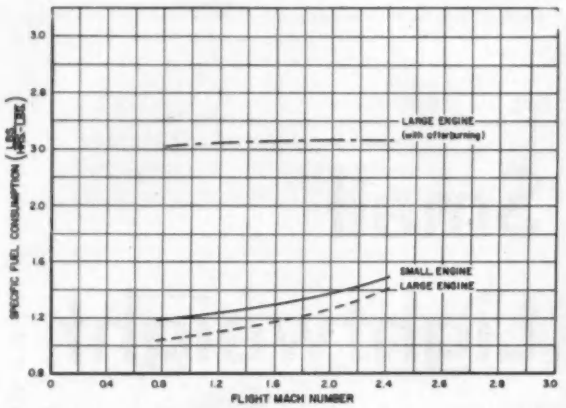


Fig. 2—Specific fuel consumption plotted against Mach number shows large engine superior to small one in subsonic region. This advantage wanes as Mach number is raised.

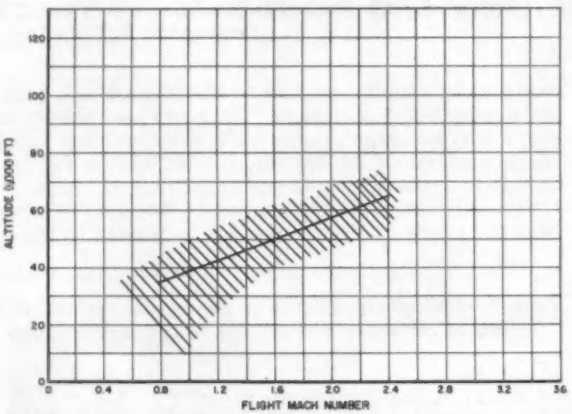


Fig. 3—Typical combinations of altitude and flight Mach number used to permit conclusions as to which engine is more attractive for applications involving variations in flight Mach number and duration. Shaded portion represents more or less complimentary values of altitude and flight Mach number normally met.

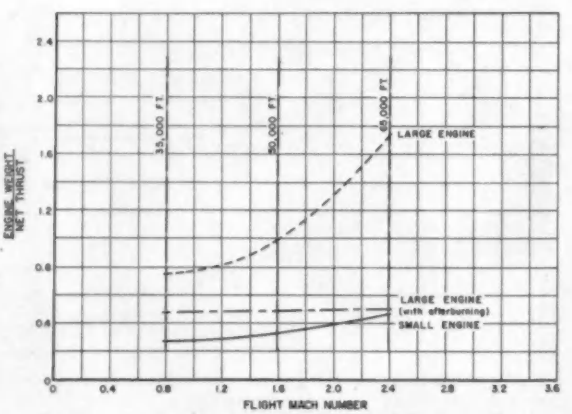


Fig. 4—Engine weight/net thrust ratios illustrate definite weight advantage of small engine package even when afterburner is used for larger engine.

where specific fuel consumption is plotted against Mach number. In the subsonic region the large engine has a specific fuel consumption about 17% lower than that of the small engine.. This difference decreases as the Mach number is raised until, at a Mach number of 2.4, there is only a 6% difference. With afterburning, the specific fuel consumption for the large engine is approximately constant at 2.4, and is more than twice the unaugmented value in the subsonic region and about 70% higher than the unaugmented value at 2.4 Mach number.

The relative effects of the depicted changes in thrust and specific fuel consumption will be examined in subsequent figures to indicate which engine might be more attractive for applications involving variations in flight Mach number and duration. In order to permit valid conclusions to be drawn from a reasonable number of figures, typical combinations of altitude and flight Mach number have been employed as shown in Fig. 3. The shaded portion of the figure represents the more or less complementary values of altitude and flight Mach number that are normally encountered. The line drawn near the center of the shaded area represents the values used in this analysis. In particular, the following pairs of values will be discussed in the remaining figures:

Mach number 0.8, altitude 35,000 ft
Mach number 1.6, altitude 50,000 ft
Mach number 2.4, altitude 65,000 ft

Fig. 4, derived from the specific thrust data previously presented, together with typical airflow versus Mach number and altitude characteristics, depicts the engine weight/net thrust ratios for the small engine package and for the large engine with and without afterburning. For the small engine package, the weight per pound of thrust varies from 0.28 at 35,000 ft and Mach number 0.8 to 0.47 at 65,000 ft and Mach number 2.4. Similar values for the large engine are 0.75 at the subsonic condition and 1.75 at the supersonic. Even with afterburning, the specific weight at altitude of the larger engine is greater than that of the unaugmented small engine package, being essentially constant at a value of about 0.5 along the flight path considered. The trends shown here are extremely significant, and indicate the decided weight advantage of the small engine package, even when afterburning is used for the larger engine. (An optimistic afterburning temperature of 4000 R and afterburner weight of 10% of the basic engine were used.)

The combined effect of engine weight and fuel consumption for the subsonic condition is shown in Fig. 5 where the powerplant plus fuel weight divided by net thrust is plotted against flight duration in hours. It is interesting to note that the total engine plus fuel weight is lower for the small engine package than for the large powerplant for all durations of less than about 3¼ hr (about 1700 miles range).

The situation for the first supersonic condition considered (Mach number 1.6 at 50,000 ft) is shown in Fig. 6. The data presented are similar to those shown in Fig. 5 except that a curve has been added for the large engine with afterburning. Here the small engine package is superior for durations up to 5 hr. This duration requires a ratio of engine-plus-fuel-weight/thrust of about 7, which, combined with an airplane lift/drag ratio not exceeding 10, would indicate that the small engine package would be preferred for all practical flight conditions. The

comparison becomes even more favorable when the effect of the gross-to-empty weight ratio discussed above is considered. The curve for the afterburning engine indicates that this configuration is never as effective as the lighter unaugmented engine package. This is, of course, obvious from Figs. 1 and 4, which indicated that at all flight conditions considered the afterburining engine is both heavier and less efficient than the smaller unaugmented engine. A further factor which would tend to favor the lightweight unaugmented engine when compared with an afterburning engine in supersonic applications is the fact that better climb and acceleration characteristics would result in the unaugmented case because of the relatively greater thrust (at a much lower specific fuel consumption) at all Mach numbers below the design flight speed.

Data for the third case considered, a flight Mach number of 2.4 at 65,000 ft, are shown in Fig. 7. Here the lightweight unaugmented engine package is markedly superior to either the unaugmented or augmented large engine. The superior performance of the small engine as compared with the unaugmented large engine results from the much lower engine weight combined with a specific fuel consumption only slightly higher. The superiority of the small engine relative to the augmented large engine derives from the much lower sfc, while the required engine weights are approximately equal.

An additional factor that would have to be considered in a more precise comparison of the unaugmented small engine versus the augmented large engine for a particular mission at high Mach numbers is the increased nacelle drag resulting from the larger air handling capacity necessary with the unaugmented engine. This effect would alter somewhat the magnitude of the results presented herein for the two supersonic flight conditions, but would not significantly affect the trends discussed. That the trends already defined would be essentially unchanged can be seen from the following discussion of the results for the Mach number 2.4 data (Fig. 7). A typical value of the nacelle drag coefficient for this Mach number might be taken as 0.10. The thrust coefficients for the non-afterburning small engine and the afterburning large engine are about 0.85 and 2.55, respectively.

To compare the two engines on the basis of propulsive thrust rather than engine net thrust, it is necessary to subtract the nacelle drag coefficient from the net thrust coefficient. On Fig. 7, this change would result in a 12% increase in both the ordinate intercept and the slope of the unaugmented small engine, and a 4% increase in each factor for the augmented large engine. The net result would be equal engine weights and a reduction in the disparity in fuel rates for the two cases. The absolute value of the fuel rate for the engine with afterburning still remains much higher than that for the unaugmented engine, so the two engines are competitive only for flights of a very few minutes.

From the data presented herein, it appears that for typical missions in the high subsonic or supersonic speed range the small, lightweight turbojet-engine package generally requires a lower weight of engine plus fuel than either an unaugmented or augumented single large engine of equal thrust.

(Paper, "Increased Mission Effectiveness through the Application of Small Gas Turbine Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications; 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

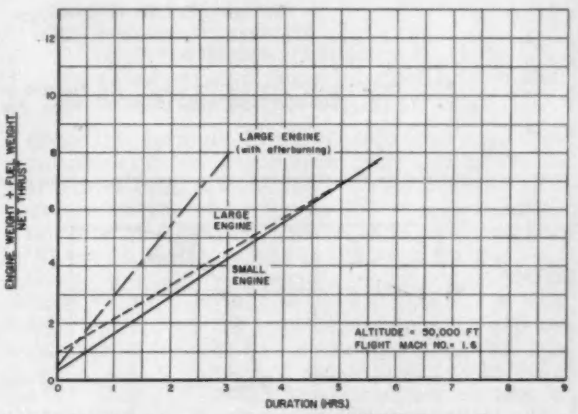


Fig. 6—At flight Mach number of 1.6 at 50,000 ft, small engine is superior to large for durations up to 5 hr.

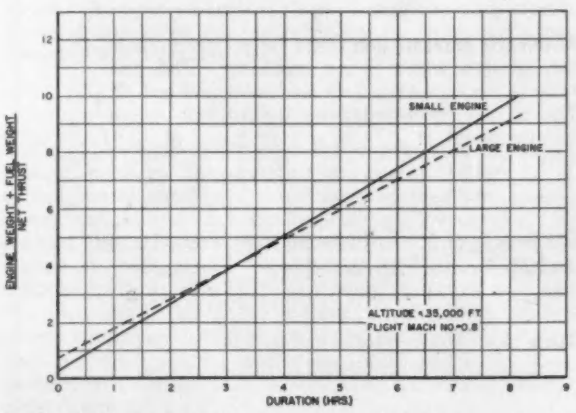


Fig. 5—Combined effect of engine weight and fuel consumption for subsonic condition shows total weight of engine plus fuel is lower for small engine for all durations of less than about 3¼ hr.

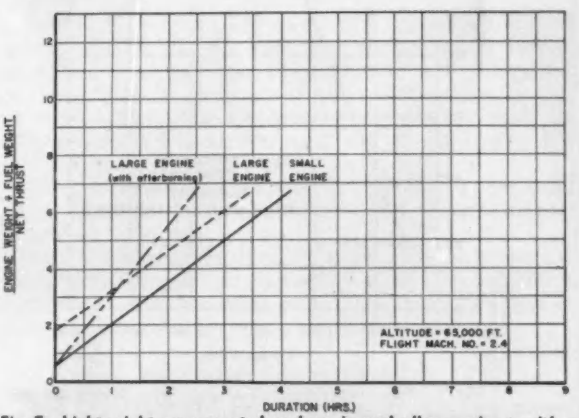


Fig. 7—Lightweight unaugmented package is markedly superior to either augmented or unaugmented large engine at flight Mach number of 2.4 at 65,000 ft.

THIS article is based on a symposium titled

"Where Does All the Power Go?"

including:

Part I—The Engine . . . The Power Source

Carl E. Burke and **Larry H. Nagler**
Automotive Research and Engineering Dept., American Motors Corp.

Part II—The Accessories—the First Bite

E. C. Campbell
Engineering Staff, General Motors Corp.

Part III—Effective Power Transmission

W. E. Zierer and **H. L. Welch**
Engineering Division, Chrysler Corp.

Part IV—Wind and Rolling Resistances

L. C. Lundstrom
General Motors Proving Ground, General Motors Corp.

Part V—What the Customer Gets

T. D. Kosier and **W. A. McConnell**
Ford Motor Co.

and a discussion by W. S. James

William S. James and Associates, Engineering Research Consultants

All of these papers (not the discussion) are available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each paper to members; 60¢ each paper to nonmembers.

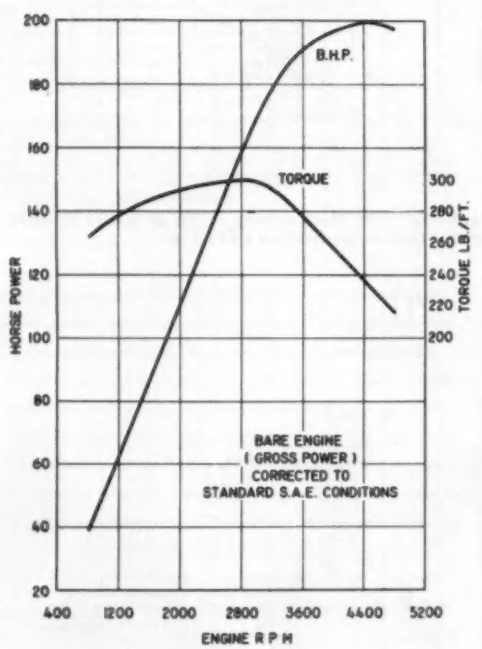


Fig. 1—Power characteristics at wide open throttle for the hypothetical engine.

FOR the purposes of the symposium, a hypothetical passenger car was assumed having these characteristics:

Bare engine at wide open throttle has the power and torque characteristics shown in Fig. 1. The 200-hp V-8 engine has a 300-cu in. displacement and an 8.5 to 1 compression ratio.

Automatic transmission has a three-speed planetary gearbox and a torque converter. The gear ratio in first speed is 2.45 and in second is 1.45. The torque converter gives a maximum torque multiplication of 2.34 at a stall speed of 1630 rpm.

Car body is of conventional styling. Frontal area is 25 sq ft.

Tires are current production 6.70 × 15 tires at standard inflation pressure. Rolling radius is 1.11 ft.

In today's admittedly powerful passenger cars, here's

Where All the Power Goes

TO show why modern passenger cars have the power they do, let's consider where the power of a hypothetical 200-hp car goes.

We'll assume for our car's engine the characteristics shown in Fig. 1. Then we'll see how the mechanical energy shrinks when we install the engine in the car and equip it with air cleaner, mufflers, fan, generator, and the other accessories necessary or desirable. We'll show how we take some further power losses in the assumed transmission, to deliver the power to the wheels at the speed we want to use it. And finally, we'll show how much power and force is required to move the hypothetical car at various speeds over the highway—that is, how much is required to overcome wind, tire, and rolling resistance losses.

What We End Up With

Then we'll sum up all these losses, subtract them from what we started with, and hope that there is still something left so that the customer can climb hills, accelerate to pass, and maybe even pull a light trailer if he wants to.

But before we start talking about all these power "losses" let's remind ourselves of what we get in return. Spending energy is like spending money; totaling up your bill and then counting your change after you've paid it is not a very good way to tell whether you got what you wanted for what you spent. Our power losses, then, should be considered as what we spent for covering travel distance comfortably and conveniently.

What We Start With

Fig. 1 on the opposite page represents the corrected, bare engine, gross horsepower. That is, it is the power obtained in a dynamometer test under these conditions: no air cleaner, no generator, no engine fan, spark and fuel adjusted to mean best power at each speed (every 200 rpm), no exhaust heat to intake manifold, and back pressure not less than atmospheric or more than 1 in. of Hg. Water pump and fuel pump were installed on the engine and were absorbing power, so that their requirements need not be subtracted from the brake horsepower shown.

Test conditions were corrected to standard conditions of 29.92 in. of Hg barometric pressure, 0 in. of Hg vapor pressure, and 60 F air temperature by the SAE's formulas:

$$\text{Corrected Bhp} = [(\text{Observed Bhp} + \text{Fhp}) \times \text{Correction Factor}] - \text{Fhp}$$

$$\text{Correction Factor} = \frac{29.92}{B - E} \times \sqrt{\frac{460 + t}{520}}$$

where,

Bhp = Brake horsepower
Fhp = Friction horsepower
B = Observed barometer reading, in. of Hg
E = Vapor pressure (from humidity), in. of Hg
t = Intake air temperature, F

From this formula, it can be seen that high temperatures and low barometric pressures affect engine power output adversely. Underhood air temperature in the car rises to 200 F under certain conditions of operation. Barometric pressures may be as low as 24.90 in. of Hg at higher altitudes.

Once the engine is installed in the car, it suffers certain other unavoidable power losses. A dual muffler system on the hypothetical engine will cut bare engine power by 7% at rated speed of 4400 rpm at wide open throttle and lesser amounts at lower speeds. A single muffler will cut power by 14% at 4400 rpm and lesser amounts at lower speeds. The air cleaner can be charged with 3% at 4400 rpm and wide open throttle, and lesser amounts at lower speeds.

Combustion chamber deposits lessen bare engine power output by 4% over the entire speed range. Manifold heat may cost as much as 5% of the power at 1600 rpm—a percentage that diminishes to 1% at 4400 rpm. The automatic distributor may be charged with 6% at 800 rpm, 4% at 1600 rpm, 2% at 2400 rpm, and 1% at 4400 rpm.

Altogether, these components plus engine deposits cause the installed engine to lose 16% of bare engine power at 4400 rpm.

Fig. 2 shows bare engine power at standard atmospheric conditions, installed power at standard conditions, and installed power adjusted to average atmospheric conditions in the Detroit area.

Accessories Get the First Bite

The first bite out of the installed engine's power goes to the fan, generator, and power steering pump. The first two have been required on cars for years,

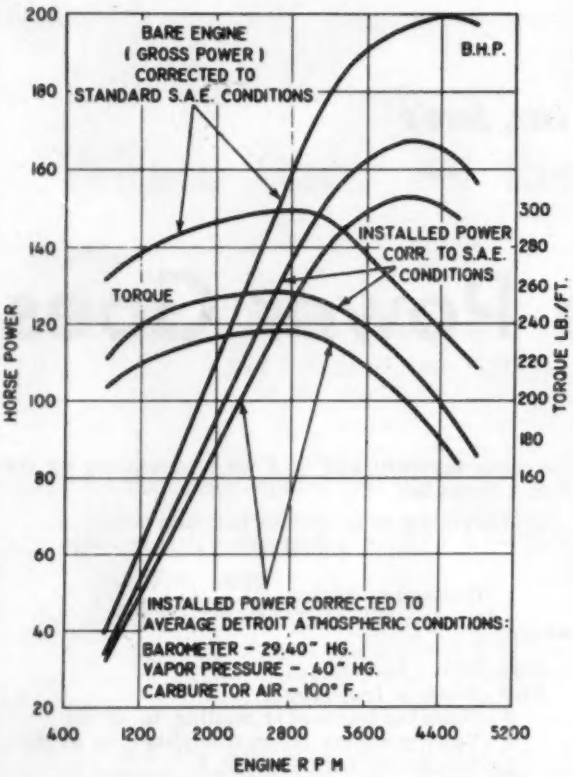


Fig. 2—Some of the bare engine's power is lost just by installing in the car and running it there. It dwindles away due to the muffler, the air cleaner, manifold heat, automatic distributor, and combustion chamber deposits. Under atmospheric conditions less favorable than standard conditions, the installed engine gives even less power.

and the power steering pump is well on its way to becoming standard equipment because of customer demand. Our hypothetical engine will have to supply the power to drive these accessories.

The fan is the most demanding of the three. The fan is basically part of the engine since its primary purpose is engine cooling. This it accomplishes by pulling air through the radiator and then blowing it back over the engine.

Years ago, most engines were rated with the fan installed on the engine so that it was not necessary to run separate fan tests and then deduct the power requirement from the engine output. Engine rating is now primarily a dynamometer laboratory procedure, and the whirling fan presents a very definite safety hazard to personnel conducting engine tests and a serious noise problem. For this reason most engines are now rated with the fan removed, and the fan is tested separately in free air on a small accessory dynamometer.)

There are several factors affecting the fan power requirements. Among these are grill styling, heat rejection of the engine, radiator efficiency, and the efficiency of the fan itself. Fig. 3 shows the horsepower requirement of an average fan for the size engine under discussion here. The curve indicates that the faster the fan turns the greater the increase in power requirement becomes; so that up in the speed range of the horsepower peak it is eating up considerable power, requiring over eight times as much power as it does at 2000 rpm—or approximately 50 mph.

The generator is a device of varying appetite which converts energy according to the loads other equipment is demanding of it. The generator supplies the electrical requirement of the entire automobile, serving to keep the battery charged and to operate the ignition system, lights, radio, heater and defroster fans, and other miscellaneous accessories the owner might decide to install. Typical of rotating electrical apparatus, it has its own blower equipment which adds to the load. Fig. 4 shows the load range within which the generator has to operate; with the load being automatically controlled by the voltage regulator. For purposes of our hypothetical engine we have selected about two-thirds of its peak requirement for an average power diversion. This is the heavy line appearing in the center of the band.

The power steering pump is another accessory which draws on the engine in proportion to the load placed on it. It can idle along taking care of the friction losses of the system it serves or it can actually go to work. To operate the power steering gear, the pump is required to provide pressure as high as 700 to 800 psi instantaneously. However, these loads are intermittent and generally occur at very low engine speeds while parking or turning corners, and the engine will only be charged with the pumping losses of the entire system. Fig. 5 shows the horsepower requirement of the power steering pump.

Now that the individual power requirements of the basic accessories are known, we can total them up and see what they do to the net horsepower available at the flywheel. On the engine power and torque graph, Fig. 6, the lower curve is the net horsepower available at the flywheel. At 50 mph the accessory demand is relatively low, in the order of only 2 hp, but up in the speed range of the horsepower peak the demand is high, dropping the peak horsepower available at the flywheel to 145 hp. Note that although the engine has a rating of 200 hp, more than 25% of the gross engine power has been used up ahead of the flywheel. Remember that so far only the average operating conditions of standard accessories have been considered.

Air conditioning, popular with car buyers in warm climates, is another accessory that consumes power. The drain is slight in the lower engine speed ranges, but at the horsepower peak 11 hp—or 7% of the net available horsepower—is used up.

The power available at the flywheel is applied to the rear wheels through the transmission.

Transmission Consumes Power But Pays Its Way

The internal combustion engine is essentially a constant torque device with practical limits as to how slowly or how fast it can run. Within those limits the engine develops power almost proportional to speed, and its maximum output, therefore, is developed at high engine speeds.

Present-day automatic transmissions, however, combine with the engine to provide the driver with near maximum power for acceleration and hill climbing ability, over a wide range of car speeds, by merely depressing the accelerator.

Each type of automatic transmission in common

usage today employs a planetary gear train in combination with either a torque converter or a fluid coupling. When a fluid coupling is used as the slipping element, a four-speed planetary gearbox is used. In the case of those using a torque converter as the slipping element, either a two- or three-speed planetary gearbox is used. For the purpose of analyzing the performance characteristics of a representative automatic transmission, a three-speed planetary gearbox with torque converter will be considered, having gear ratios of 2.45 and 1.45 in first and second speed, respectively. The torque converter gives a maximum torque multiplication of 2.34 at a stall speed of 1630 rpm.

When one thinks of the components required to perform automatically the function of providing the proper gear ratio for performance or economy as well as neutral and reverse—the friction bands and clutches and hydraulic pumps to energize them—it is not surprising that additional power is required for their operation. Then there is the efficiency of the hydrokinetic torque converter, which is such an important element of the transmission.

Fig. 7 shows that with the input horsepower of 145 at 4000 rpm which might be expected from the engine developing 200 gross hp at 4400 rpm, the automatic transmission delivers 135 hp at 3800 output rpm in direct, 131 hp at 2600 rpm in second, and 127 hp at 1600 rpm in low gear. These peak values represent 93, 90, and 87% of the input horsepower, respectively.

The torque curves are shown in Fig. 7 since torque is the form of output that permits an evaluation of performance irrespective of speed. Note that the automatic transmission multiplies the engine torque nearly six times for initial starting and greatly enhances performance throughout the normal speed range.

Fig. 8 shows the power and torque output from a three-speed manual transmission, with the same 145 hp engine supplying the input. For this analysis, a typical gearbox of the reverted gear train type was used. Gear ratios of 2.55 and 1.60 for first and second gears were selected as typical, with high being direct.

Power delivered to the propeller shaft would be 143.8 hp at 4000 rpm in high, 141 hp at 2400 rpm in second, and 137 hp at 1500 rpm in first gear. These values are, respectively, 99, 97, and 94.5% of the input power.

The mechanical efficiency of the manual transmission is indeed excellent, but its good performance potential at low propeller shaft speeds is

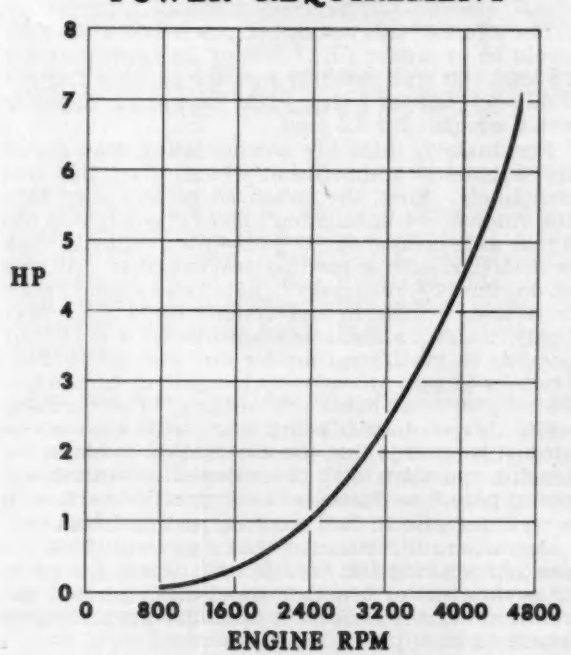


Fig. 3—The faster the engine turns, the more power the typical simple fan eats up.

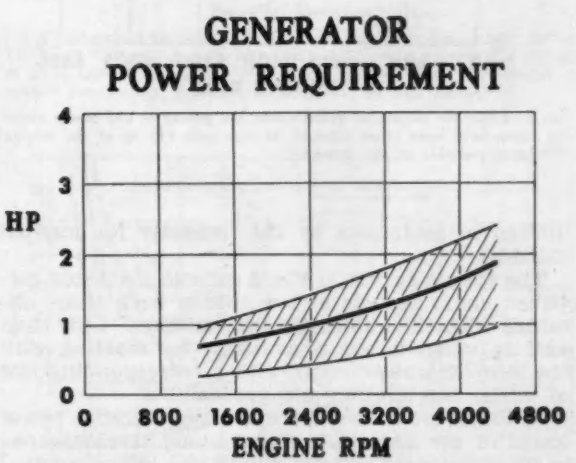


Fig. 4—Generator takes shaft power and converts it into electrical power to supply all of car's electrical equipment. Since it generates waste heat as well as the desired current, it has its own power-using blower. Heavy line shows load assumed for the hypothetical case.

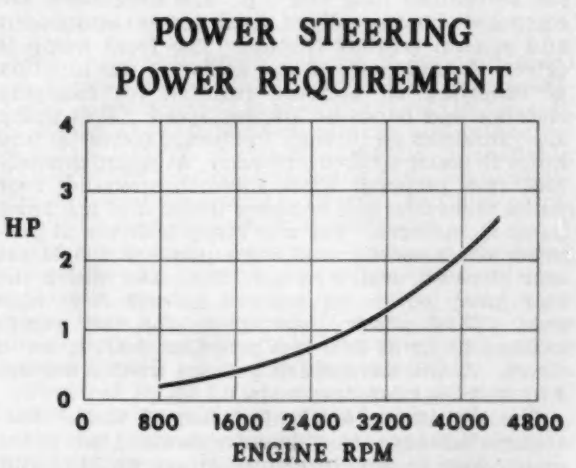


Fig. 5—Like generator, power steering pump's power requirement depends on load on it. Heaviest loads are due to parking or turning corners. But even when system is idling it draws some power to take care of its friction losses, plotted here.

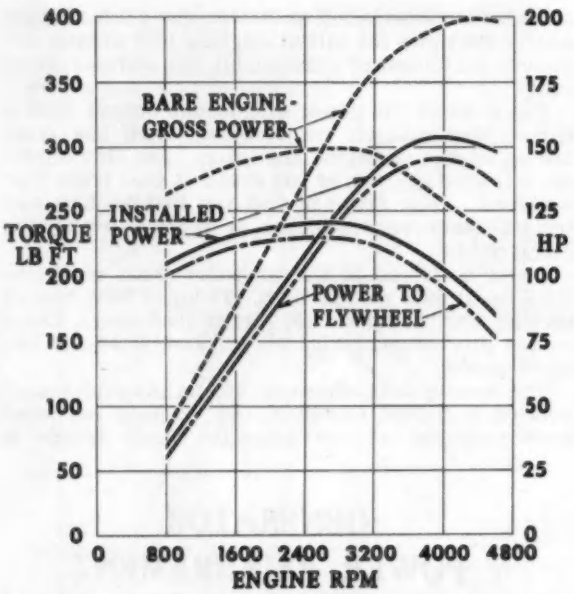


Fig. 6—After the engine accessories and the generator and power steering pump have been taken care of, at best only 145 hp of the original 200 hp is available at the flywheel.

limited in usefulness by the necessity for manual shifting.

The torque curves in Fig. 8 exhibit a notably different characteristic at low speeds from those obtained with the automatic transmission. Less than half as much torque is available for starting with the manual transmission, with a corresponding loss of initial acceleration and gradeability.

In Fig. 9 are shown the wide-open-throttle power losses of the automatic and manual transmissions in direct gear. The total power loss in the manual transmission is very small, being only 1.4 hp at 4400 rpm and is attributable to bearing and seal friction and lubricant churning losses.

Power losses in the automatic transmission are in two categories: drag and slip. The drag losses are composed about equally of pump power requirement and general gearbox friction. The front pump is driven at engine speed and performs the function of supplying oil pressure required for engaging clutches and bands at low car speed. This pump also circulates oil through the torque converter and keeps it under desired pressure. At approximately 1500 rpm propeller shaft speed, the smaller rear pump takes over the pumping duties and the front pump is unloaded. The rear pump is driven at propeller shaft speed. The front pump is the larger user of power until it is unloaded, after which the rear pump power requirement exceeds it in high gear. Total power absorbed by the two pumps reaches 4.4 hp at 4400 rpm propeller shaft speed in direct. At this same speed, gearbox friction absorbs 3 hp and the band drag a low 0.3 hp.

The slip loss is a manifestation of torque converter efficiency. At wide open throttle, this is the major loss in the transmission up to 3400 rpm propeller shaft speed. The very large power loss indicated at low speeds reaches a maximum at standstill or "stalled" condition where torque multiplication is maximum and output power is zero. The entire engine output of 69 hp at the stall speed of 1630 rpm is lost since no external work is accomplished. However, the very high torque developed is of great utility for quick starting. In practice, this loss at stall speed is a transient condition of very short duration. The entire range of high power loss is of relatively little significance in regard to fuel economy under most operating conditions because of the time factor.

The sharp peak in the torque converter loss curve at 2000 rpm propeller shaft speed corresponds to the converter output-to-input speed ratio where torque multiplication stops and fluid coupling action begins. This drop in efficiency at the transition from converter to coupling is present in all torque converters to a greater or lesser degree. Those having less of a drop in efficiency at the coupling point generally suffer in efficiency at lower numerical speed ratios. At higher speeds, the torque converter steadily improves in efficiency, reaching 97% at 4400 rpm propeller shaft speed. The corresponding power loss at that speed is 4.3 hp.

The transmission power losses in first and second gear at wide open throttle are compared with high gear losses in Fig. 10. It is apparent that at low speeds the effect of the converter loss is minimized due to the gear ratios. As might be expected, however, the drag friction increases when the power is delivered through the planetary gears. Thus the wide-open-throttle power losses in the automatic transmission are appreciably higher than in the manual transmission, whether in first, second, or high gear.

For comparison with the wide-open-throttle losses, a bar has been drawn on Fig. 10 showing the road-load loss in the automatic transmission at a car speed of 50 mph. The total loss of 2.6 hp shown is comprised of 1.8 hp friction and 0.8 hp converter loss.

The effect of this amount of power loss at 50 mph would be to reduce fuel economy by approximately 1.8 mpg. Of this economy loss, the gearbox friction would account for 1 mpg while the torque converter would account for 0.8 mpg.

Fortunately, there are compensating features of the automatic transmission which offset this loss completely. First, the enhanced performance with the automatic transmission makes it possible to use a rear axle ratio about 12% lower numerically than is desirable with a manual transmission. At this speed, the 12% reduction in axle ratio should result in an improvement in fuel economy of 1.5 mpg. Secondly, with an automatic transmission it is usually possible to modify carburetor and distributor calibrations to gain an economy increase of from 0.1 to 0.3 mpg without noticeable surging. Furthermore, while this analysis is being made with a given engine, it is possible that the elimination of low speed lugging operation with the automatic transmission would permit an increase in compression ratio with a resulting gain in fuel economy and performance.

Any loss in fuel economy that may result from the use of the automatic transmission is not the effect of equilibrium or constant speed driving but is the result of warm-up effects or other driving conditions where unusually high slippage occurs.

Although the convenience of "no shift" driving might justify the power absorbed in an automatic

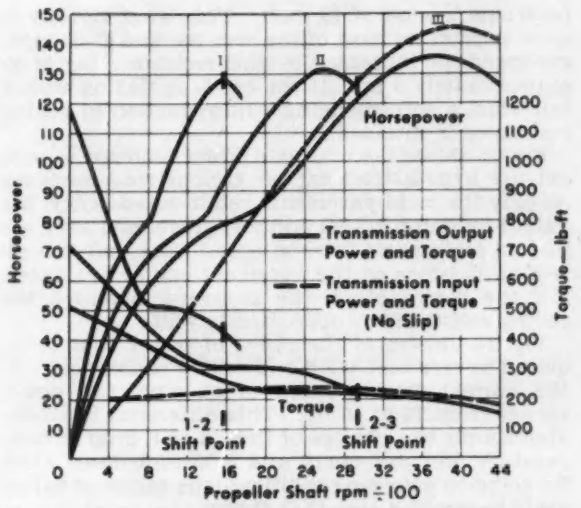


Fig. 7—With 145 hp at 4000 rpm delivered to the automatic transmission, it will deliver 135 hp at 3800 rpm in direct, 131 hp at 2600 rpm in second, and 127 hp at 1600 in low gear. High torque for starting is available at low speeds.

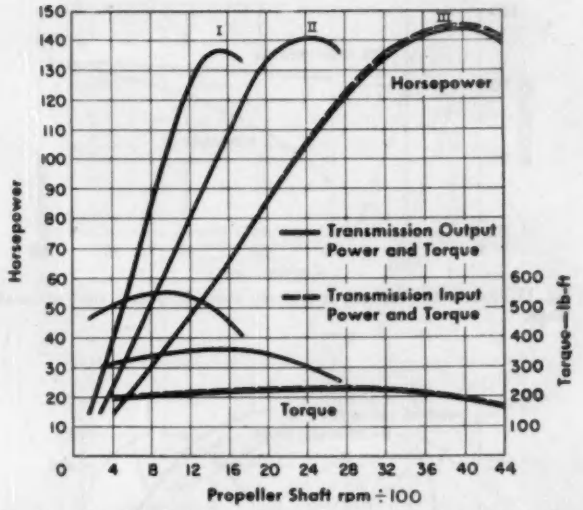


Fig. 8—Manual transmission supplied 145 hp as in Fig. 7 will deliver 144 hp at 4000 rpm in high, 141 hp at 2400 rpm in second, and 137 hp at 1500 rpm in first gear. But at low speeds, where high torque is needed for starting, manual transmission offers less torque

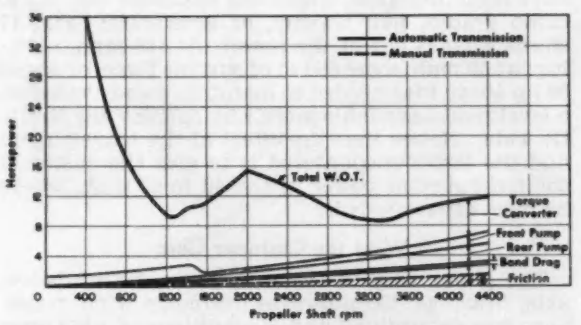


Fig. 9—Automatic transmission in direct gear wastes more power than manual transmission does—but the difference is unimportant because automatic transmission's big losses occur only for short periods.

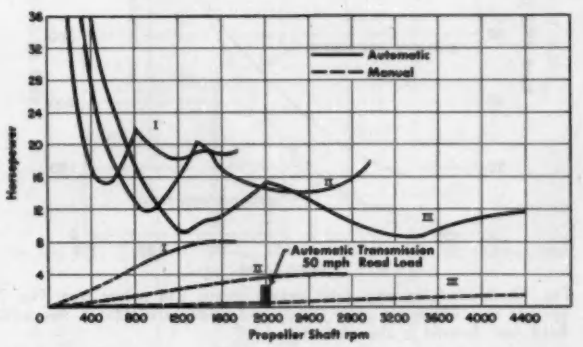


Fig. 10—Power losses at wide open throttle are higher in all gears with automatic than with manual transmission. However automatic transmission has features which more than compensate for this difference.

transmission it would be wrong to think of it as a power-consuming luxury. The transmission makes the high speed power potential of the engine readily available at all car speeds. It also provides road-load cruising with relatively low engine speed, for maximum benefits in the form of smoothness and quietness.

Rear Axle Power Overcomes Air and Rolling Resistance

The data shown in Fig. 11 illustrate that the overall efficiency of a typical axle is 95 to 97% under low-speed road load conditions. Seal friction, churning losses, and bearing losses probably account for the lower efficiency under light load conditions.

The available or maximum axle torque and axle power plotted in Fig. 12 were obtained by applying the rear axle efficiency of Fig. 11 to the prop shaft output torque and power of Fig. 7.

Also plotted on Fig. 12 are the assumed road load axle torque and axle power curves for the theoretical 4000-lb car. This road-load torque supplies the force required to propel the car at constant speed on a level, hard-surfaced road, under ideal conditions. As the vehicle is in equilibrium, the force is, of course, equal to the sum of wind and rolling resistances. When a complete vehicle is available, axle or wheel torquemeters can be installed to measure the road load torque directly, and the corresponding road load power is computed.

The intersection of the road-load axle power and maximum axle power curves define the theoretical maximum speed of this car. As plotted, the vehicle would have a top speed of 105 mph, but this value could vary considerably if the wind and rolling resistances are above the ideal minimum. In the high-speed range for this car, nearly 4 hp are required to increase the car speed 1 mph.

Rolling resistance varies somewhat for tires of different compositions, construction, sizes, loads, and inflation pressures.

Higher inflation pressures will reduce the tire deflection and flexing and, consequently, the rolling

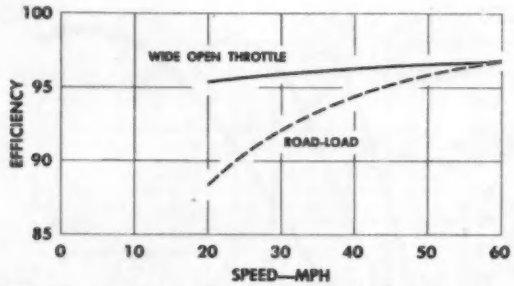


Fig. 11—Rear axle efficiency is typically above 88% over most of speed range.

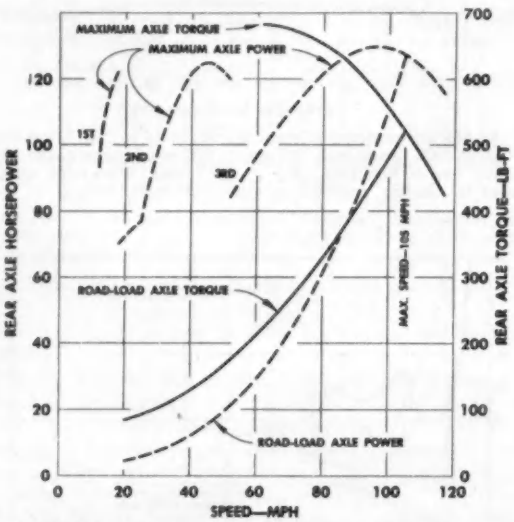


Fig. 12—Multiplying prop shaft output torque and power from Fig. 7 by rear axle efficiency gives torque and power available at the axle. Road-load demand is also plotted here.

resistance. For high-speed driving, the reduction of resistance with higher inflation pressures also shows up in terms of lower tire temperature.

Precision road tests now have confirmed earlier opinions that air temperature has a very definite effect on road load torque and power requirements. Fig. 13 illustrates the variations in power that can be expected for the theoretical car when operating in 30 F, 50 F, and 70 F air. The 70 F curve is identical with the road-load axle power curve shown on Fig. 12. Note that at 60 mph 5½ more hp are required to propel the car at 30 F than at 70 F. This amounts to approximately ½ of 1% change in power requirement per degree of temperature change, or 20% change between 30 and 70 F. In the normal temperature range, this change or variation with temperature is approximately linear.

For simplification of engineering studies, the air and rolling resistances usually are computed for still, ambient air conditions. However, natural wind currents either may increase or decrease the air resistance factors, depending upon direction of the wind. This is illustrated on Fig. 14 by plotting the power required to overcome the air and rolling resistances plus (or minus) the additional power to overcome a wind of 13 mph. This wind velocity is quite normal for most of the country, and at 60 mph, car speed can increase the wind resistance factor by approximately 5 hp. If the car is operating with a tail wind, a corresponding 5 hp reduction in rolling resistance is obtained.

Fig. 15 shows the rear axle power required to propel the hypothetical car on various road surfaces. As only the rigid pavements retain consistency, the values for damp gravel and soft gravel and sand are plotted for general interest only. Note that the effect of moisture on the pavement can be evaluated. For the data plotted, the moisture increased the rolling resistance by approximately 5%.

Fig. 16 illustrates the range of power that is required to overcome wind and rolling resistances. At the normal driving speed of 60 mph, the power ranges from 29 to 49 hp. This difference is attributed simply to a change of tires, a 40 F drop in temperature, wet pavement, and a 13-mph head wind. By going to extreme conditions, the range of values could be doubled over that shown.

Variations in fuel consumption are even more striking than the variations in road load axle power requirement.

By subtracting resistances from the tractive effort, we find the surplus pulling force, after all losses have been overcome, which the customer can use to climb grades, pull trailers, or accelerate. Fig. 17 shows what is left of the power: At 100 mph, nothing; at 50 mph, some 650 lb of surplus force, or about 88 hp above that needed to maintain steady speed on a level road—available merely by opening the throttle wide. Notice that the effect of the transmission and the losses encountered is to give the customer the most surplus power in the 40 to 60 mph, where he most often needs it.

What the Customer Gets

The power used in the accessories, transmission, axle, bearings, tires, and to overcome wind resistance was determined under conditions of wide open throttle, and will be the same at steady speed on a grade as at steady speed on level ground. The weight of a vehicle is always a force acting straight down. So in climbing a grade, this weight will have a component parallel to the pavement, and a slightly diminished component perpendicular to the road, which has no significant effect on our performance. Thus, on a 10% grade, about 10% of our vehicle weight, or 400 lb, is the component in the direction of travel which must be equalled or balanced by the surplus thrust—or drawbar pull as it is sometimes called by test engineers, even though automobiles don't have drawbars like trains and tractors to which this pull can be hooked.

By converting the surplus force scale of Fig. 17 into the slope which will produce a down-grade weight component equal to that force, we get the grade capability envelope in Fig. 18. This tells us what grades we can climb—and how fast.

There are only three things our customer can do to put his car where he wants it on the highway. He can start it, he can point it, and he can stop it. In order to keep his car in a spot on the road which is temporarily unoccupied by another vehicle, it is desirable that he be able to do these things rapidly. He wants his car to accelerate rapidly on demand. We have already seen how the automatic transmis-

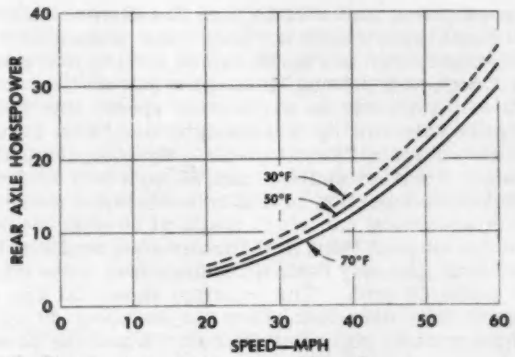


Fig. 13—Tires require more power in cold weather.

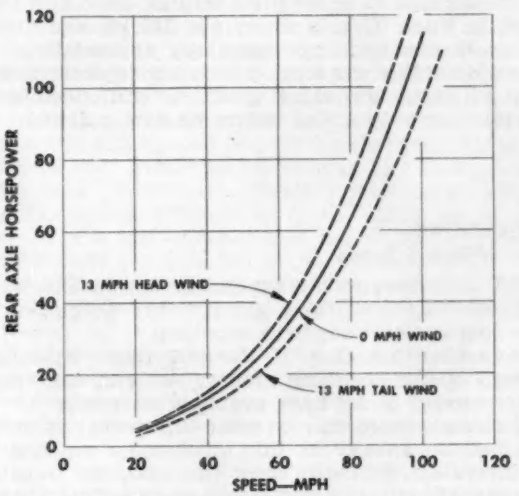


Fig. 14—A headwind demands extra power.

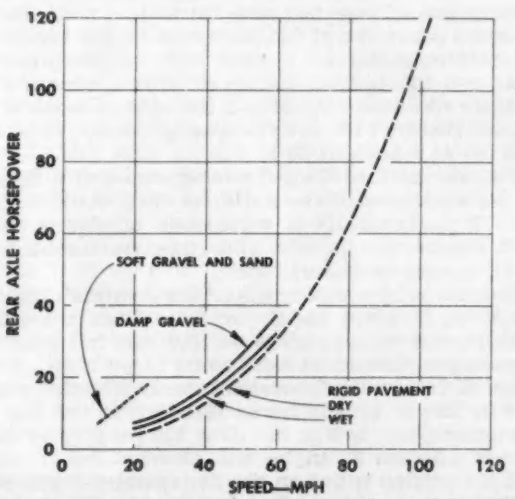


Fig. 15—Soft or wet surfaces require more power than rigid dry surfaces.

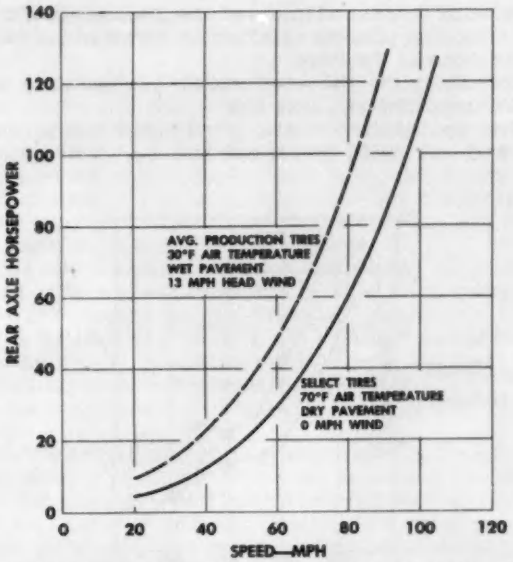


Fig. 16—At 60 mph power requirement to propel car may be as low as 29 hp under favorable conditions or as high as 49 hp under less favorable—but frequently encountered—conditions.

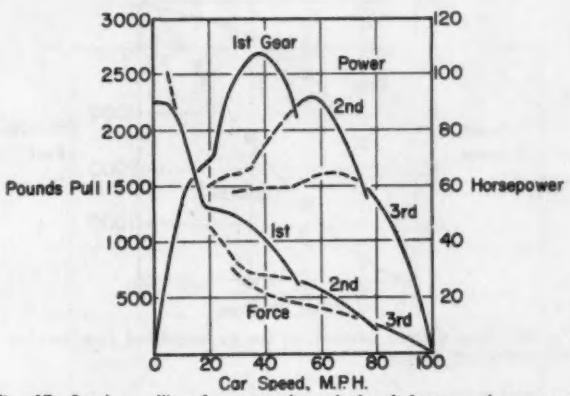


Fig. 17—Surplus pulling force can be calculated from surplus power available.

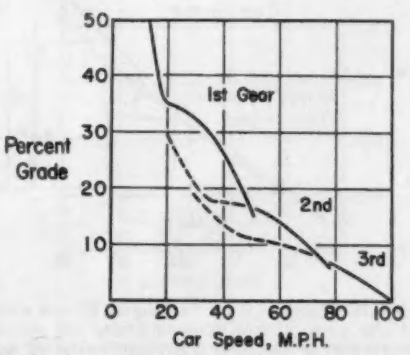


Fig. 18—This grade climbing ability envelope is derived by converting the surplus force scale of Fig. 17 into the slope which will produce a down-grade weight component equal to that force.

sion helps him use as much of the available power of his engine as possible at whatever speed he happens to be going at the time.

Fig. 19 shows the acceleration performance the power available will give him.

The acceleration versus speed curve can be used to find out what the speed will be after various elapsed times, and also to find the distance which will have been travelled. Such time-distance relationships, shown in Fig. 20, can be used to find passing times, and passing distance required.

If a car travels at a constant speed, the time-distance relationship is a straight line, with different slopes for different speeds. By comparing the straight line representing, say, 50 mph and uniform speed with a portion of the time-distance curve of our hypothetical car which starts at 50 mph, we can find the elapsed time, and the distance required for our car to gain any desired distance over some other car going 50 mph. The example shown in Fig. 21 depicts this situation. Our car is going 50 mph behind another car going 50 mph. When the throttle is opened, we begin to accelerate, and our time-distance curve begins to rise above the uniform time-distance line of the other car. After 6 sec have elapsed, and we have travelled 520 ft, the other car will have travelled 440 ft, and we have gained 80 ft—enough to come from behind, pass, and pull back in line. This is where our 200 hp and automatic transmission are especially appreciated. If there is another car coming from the opposite direction at about the same speed, we still need over 0.2 mi clear road ahead before we dare pull out.

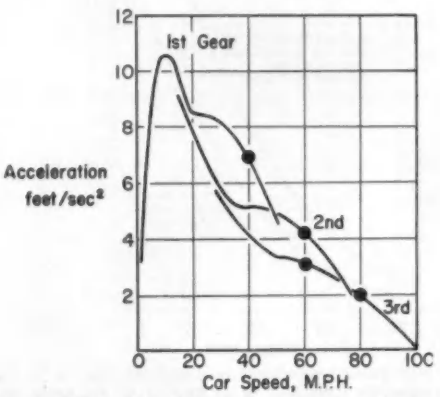


Fig. 19—This is the acceleration performance the customer can get from the hypothetical car.

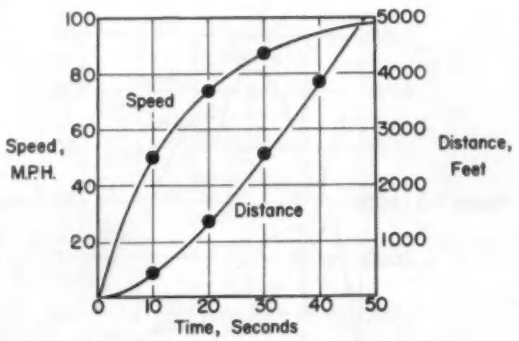


Fig. 20—Time-distance relationships can be established from acceleration and speed data.

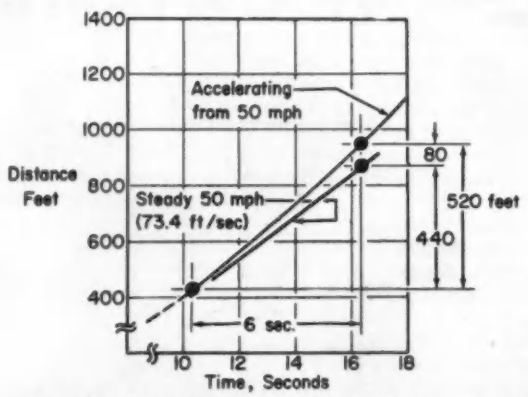


Fig. 21—When the hypothetical car traveling at 50 mph wants to pass a car ahead also going 50 mph, former's engine will provide enough power for acceleration so that after 6 sec, hypothetical car has traveled 520 ft, other car has traveled 440. The difference of 80 ft is enough to allow the hypothetical car to come from behind, pass, and pull back in line. This is where the "200 hp" engine pays off!

Discussion

—William S. James

JUST to review, we can summarize the various ways in which the working gas pressure developed in the combustion chambers was used.

Following the line of thought that "Spending energy is like spending money," we can ask "How much energy do we have available to spend?"

Although there may be some differences of opinion on the answer to this question, a reasonable estimate can be made from the excellent work of Hershey, Eberhardt, and Hottel on the "Thermodynamic Properties of the Working Fluid in Internal-Combustion Engines" (SAE Transactions, Vol. 31, 1936). When the rather complicated relations between gas temperature, dissociation, change in specific heats with temperature and pressure, and other factors, are allowed for, they estimate a mep (mean effective pressure) of 225 psi would be the theoretical maximum for an engine with 8.5 compression ratio and the cylinders charged with a combustible mixture of about 91% of the theoretical amount of dry air required for the chemically correct combustion, at 14.7 psi and 60 F.

This means that the net average (mean) ordinate of the work area of the indicator card would be 225 psi. It assumes 100% volumetric efficiency, zero heat loss to the jackets, and complete combustion of all the air in the cylinders.

This could be considered as Aunt Jemima's legacy. We know it could hardly be more than a certain amount, but we also know we had best not plan on spending as though we were going to get it all. This value of maximum theoretical mean effective pressure is shown by the horizontal line at the top of the accompanying Fig. A. (The 225 psi mep at 4000 rpm in a 300 cu in. engine will give 340+ hp.)

If the engine is put on the dynamometer and run equipped as it will be when installed in the car and

supplied with air at the temperature, pressure, and humidity that it will receive when under the hood of the car, it will indicate on the dynamometer a torque which will correspond to a mep as shown on the fifth curve from the top, labeled "Mep at Flywheel." The mep's indicated on this curve represent that portion of the total theoretical energy available in the cylinders that finally leaves the engine as mechanical energy and is passed on into the transmission.

What has happened to that 340+ hp? It is down to 145+ hp! Nearly 200 hp lost? No, not lost, just spent. But what for?

The "accessories"—namely the radiator fan, generator, muffler, air cleaner, manifold heat, combustion chamber deposits, and distributor advance curve take about 33 hp. The engine friction, including the piston and ring friction, the water pump, the fuel pump, the bearing friction, and the charge pumping loss take about 44 hp. The correction for having air entering the engine at 29.00 instead of 29.92 in. of Hg, its temperature being 100 F instead of 60 F and the humidity being the equivalent to 0.40 instead of 0.0 in. of Hg accounts for about 16 hp. These items together with the 145+ bhp total to 238 hp which can be accounted for. The difference between this 238 hp and the 340 hp theoretically possible, or 102, is the result of heat loss to the cylinder walls, volumetric efficiency lower than 100%, and incomplete combustion of the air in the cylinders. The actual effective mep has shrunk from the theoretically possible 225 psi to a maximum of 117 psi at 2400 rpm and 96 psi at 4000 rpm.

So far we have spent quite a little of our energy on "accessories," but the engine would not run well without these expenditures. We have also spent energy on overcoming engine friction, certainly a necessary expenditure. Then we have spent some on correcting for differences in barometric pressure, atmospheric humidity, and ambient temperature. This is like saving against a rainy day. The rest—the 102 hp going to the cylinder walls, incomplete combustion, and so forth—is a kind of inheritance tax on Aunt Jemima's legacy. Some day this tax may be reduced.

What is the horsepower of the engine? 340? 238? 145? Possibly it all depends on how you look at it.

Now let's look at what happens in the transmission and axle. Directly below the curve of mep at the flywheel are three curves, one solid, one dotted, and the other dashed. These are the three curves showing the cylinder pressures equivalent to the torque reaching the axle shafts. The solid line represents the mep reaching the wheels when the transmission is in first or low gear. The two solid lines near the bottom of the plot are the cylinder mep's that are required to overcome the rotating inertia of the engine and driving train and also the rolling resistance of the vehicle (tire losses, air resistance, and so forth). The upper of the two solid curves is the sum of the rotating and rolling resistances of the car and its driving train when in low gear. The lower curve shows the rolling resistance alone. The three figures along the lower curve—20, 30, and 40—indicate the road speed of the car when in low or first gear and the corresponding engine rpm. It will be noted that below 20 mph the inertia resistance is much greater that the rolling resistance. It will also be noted that at wide open throttle the rpm of the engine is never less than 1650. This is the full-throttle "stall speed" of the torque converter.

The distances between the curve of mep at the axle shafts and the rolling and rotating resistance curves represents the cylinder pressure remaining to accelerate the car or push it up hills. The shorter distance represents the cylinder pressures available for car acceleration on a level road. The longer distance is the cylinder pressure available for hill climbing at a constant speed.

The similar sets of curves for second gear and third or high gear are shown in dots for the second gear and dashes for the direct or high gear. The curve for high gear mep at the axle shafts and that for the rolling resistance in high gear intersect at 100 mph, about 4100 rpm and 84 psi, or about 130 hp. We have spent about 15 hp in the transmission and axle.

As the article shows the power available for acceleration to give agility to the car in traffic, on hills, and for towing is over 100 hp in first gear, 90 hp in second, and over 60 hp in direct. This gives a very clear picture of the performance requirements of the present-day passenger car.

Aunt Jemima's legacy is spent. If we have bought what we wanted, was it wasted?

Horsepower race? Possibly. It might also be satisfying a very necessary requirement for a nimble car.

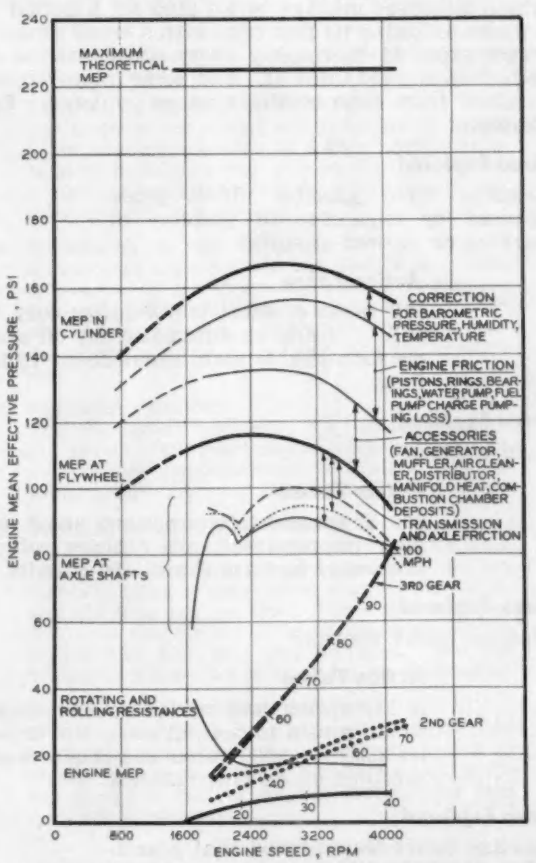


Fig. A—Where the energy, in terms of mean effective pressure, goes.

How Pacific T&T Improved

Gas Mileage to give

Action was taken in every mechanical area explored. But

A 3-YEAR campaign to reduce gasoline consumption by its fleet of vehicles is netting Pacific Telephone & Telegraph Co. an estimated $40,000 per year saving. This accrues from an improvement in mileage for the fleet of slightly over 1 mpg . . . from 10.3 mpg at the beginning of the 3-year campaign to 11.4 mpg at the end.

Before arriving at a driver training program—which improved mileage by 2.4 mpg for a period of 6 weeks following its first trial with a small group—PT&T explored thoroughly every other avenue to reduction it could think of. And, some improvement resulted from each of the avenues explored. For example:

Area Explored

Leakage from gasoline filter pipes. (caused by expansion of gasoline or parking on uneven ground.)

Action Taken

Fill tanks of short-trip vehicles only ¾ full . . . using an automatic cut-off nozzle with pliable brass snout about 13 in. long.

Area Explored

Cold engines.

Action Taken

180 F thermostats produced about 0.5 mpg improvement on vehicles which previously had 140 F and 160 F units.

Area Explored

Manual choke control.

Action Taken

A 15¢ spring was added so the choke would return to normal when the driver let loose . . . AND automatic chokes were specified on all new vehicles.

Area Explored

Mileage meter tests proved that practically all PT&T vehicles were capable of delivering 3.6 to 5.5 mpg more than was currently being obtained.

Action Taken

Mileage meter and vacuum gage tests; check in traffic on hills, on the open road; talks with drivers who had competed in economy runs . . . led to conclusion that only the driver could bring the desired results. So, a driver training program was formulated.

Area Explored

Maintenance procedures.

Action Taken

Use of a combustion analyzer in making carburetor adjustments brought an overall improvement of 0.24 mpg for the entire fleet.

Driver Program Cuts Mpg

The program formulated brought immediate results. Given first to a group of drivers at one location, the group improved 2.4 mpg for a period of six weeks following completion of the course. Later checks on this same group showed they had dropped back to 1.2 mpg improvement over their original mileage.

Then the course was tried out on top management —which became convinced of the soundness of the approach and gave the green light to full application.

Local PT&T garage foremen were first trained, then used as instructors in their respective districts. They were equipped with:

1. *Flip chart*—covering background information, reasons for undertaking the program, and recommended driving techniques to increase gasoline mileage.

2. *Booklet*—"Don't Look Now but Your Gasoline Is Showing." It covers the nine basic driving rules in which the drivers are trained. A

$40,000 Savings per year

a driver training program brought the biggest returns.

Based on paper by **A. A. Keefer,** Pacific Telephone & Telegraph Co.

booklet is given to each driver at the end of his course.

3. *Mileage meter and vacuum gage*—These are used in actual driving demonstrations.

Many of the drivers who have taken the course have become so interested that they have purchased a vacuum gage for their own use . . . and some have even instructed their families in its use.

PT&T feels it has proved that "the nut behind the steering wheel is the one that should be given a double-coating of chrome . . . and the chrome kept bright."

(Paper, "Efficient Operation of Gasoline-Powered Vehicles" on which this abridgment is based, is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

NINE DRIVING RULES, detailed here, are the basis of a driver training program which has been instrumental in improving the average mileage of Pacific T&T's fleet from 11.4 to 10.3 mpg in a 3-year period.

1. **THE GETAWAY**
When leaving a signal, don't try to win a race to the next one. On one test we did just this and averaged 8 mpg. Repeating a test over the same route, but using less speed when leaving signals, we averaged 15.3 mpg and took only 1 sec longer to cover the same distance (approximately one mile).

2. **SHIFTING SPEEDS**
Shift to high gear as soon as possible. At 20 mph, second gear uses 15–20% more gasoline than high, first gear 30–50% more.

3. **DRIVING SPEEDS**
The following list shows the gasoline milage at various speeds of a car capable of 20 mpg at 20 mph.

Constant Speeds

Mph	Mpg
20	20
30	19.7
40	18.3

4. **JACK RABBIT DRIVING**
Don't hop around in traffic. Everytime you speed up to get to the other lane you over-use the accelerator pump and it pumps gas right out the exhaust. This type of driving can use as high as 30% more gasoline.

5. **PACING YOURSELF IN TRAFFIC**
Try to make the signal and not have to speed. Avoid unnecessary stops in traffic. Accelerating from 15 to 30 mph then slowing down rapidly to 15 and accelerating back to 30 in high gear averaged 6.5 mpg on a test run.

6. **WARMING UP THE ENGINE**
If necessary use the choke but push it in as soon as possible. If it's an automatic choke be sure it's adjusted, and don't pump the accelerator. Just allow engine to operate at a moderate speed during warmup period. This one is a big gasoline saver.

7. **NEEDLESS IDLING**
This one doesn't need proof, it's just good reasoning to shut off your engine when parked, but nevertheless this same needless idling costs most people 5–10% more for gasoline than is necessary.

8. **TAKE IT EASY ON THE CLUTCH**
On one of the test routes there were two hills. During the first test run over this area the car was held uphill at the stops by slipping the clutch, and 10.3 mpg was averaged. The second test over this area the car was held at the stops by the brakes and 13.7 mpg was averaged. Use the brakes on a hill—it's safer and more economical.

9. **TAKE IT EASY ON THE BRAKES**
It takes gasoline to move your car, so anticipate traffic and you won't have to use your brakes so much. When you have to use brakes you waste the energy it took to get you moving and that means wasted gasoline.

8 case histories show way to get . . .

Precision Machining

PRECISION costs money . . . and the last few ten-thousandths cost the most.

To keep costs down, designers should permit the largest possible limits consistent with quality of product. If really close tolerances are required, then it is essential to:

1. Give the machine tool builder all information about requirements.
2. Maintain strict quality control on preceding operations.
3. Keep equipment in almost perfect condition to do the work.

Analysis of a series of specific, familiar aeronautic and automobile parts production procedures makes this clear.

Take, for instance, a turbine blade made of nimonic steel. To get a finish approximating 125 micro-in. it was necessary to feed at a rate of 0.060 in. per revolution of the cutter and revolve the workpiece at 8 rpm. The high speed steel cutters of 1¾-in. diameter revolved at 70 in. per min. The resultant finish is due almost entirely to using a progression down the blade after each 0.020 in. revolution of the blade.

To get a better finish would require a slower progression, while a poorer finish would result from a faster progression. On a blade of this type, approximately 0.010 in. of stock is left for removal by belt sanding, but the accuracy of the blade as milled is ± 0.003 in., measured at any coordinate.

Speeding up the milling cycle means more time spent in polishing. One has the choice of spending time milling and doing less belt sanding, or vice versa. Of the two, the more careful milling gives better accuracy.

Suppose we take a thinner, stainless steel blade. To hold an accuracy of ± 0.003 in. it was necessary to feed at a rate of 0.005 in. per revolution of the cutter, with the blade revolving at 8 rpm. Here, progression down the blade was 0.005 in. instead of the relatively fast 0.020 in. used with the first blade.

The difference in feed rates between these two blades is due almost entirely to the difference in blade strengths. Great consideration must be given to feed rates if required accuracy is to be retained.

The accuracy obtained from knee and column

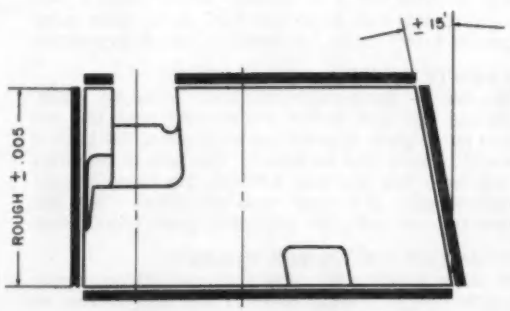


Fig. 1—An automotive cylinder head, showing dimensional tolerances possible with rough broaching.

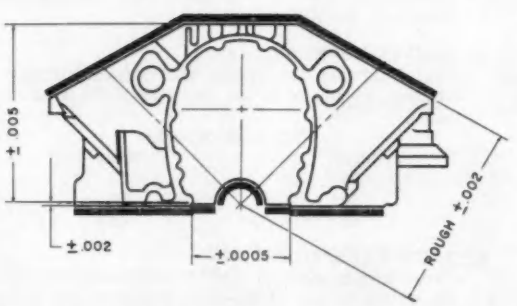


Fig. 2—A typical rough broaching operation on an automotive cylinder block, showing tolerances on bearing locks.

at Least Cost

Based on paper by **Carl M. Beach,** Cincinnati Milling and Grinding Machines, Inc

milling machines under the best conditions cannot exceed the accuracies built into them. And the accuracy of any milling job depends on a number of variables. Some of these are: the feed rate of the workpiece, the number of teeth in the cutters, the cutter rpm, the rigidity of the workpiece, and the rigidity of the fixture or holding device. Each milling job must be considered separately before an index of accuracy and surface finish can be ascertained.

Next we have an example of broaching. Here we consider a cylinder head, the end view of which is shown in Fig. 1. Customary practice calls for broaching the top and one side in one fixture of a horizontal broach, locating from three foundry locating posts, one each in two of the valve chambers and one on the joint face. This gives a flatness of 0.001 to 0.002 in., depending whether the tools are freshly sharpened or ready to be sharpened. In the second mixture, the practice is to broach the joint face and other side at one stroke, locating from the two previously broached surfaces. The resulting cylinder head should have a dimensional tolerance on its height well within ± 0.005 in. Actually, tolerance can be held to ± 0.001 in., but this is not required because there is normally a finish broaching or milling operation later on the joint surface. Angularity relationships can be held to $\pm \frac{1}{4}$ deg.

These results are obtained on cast iron cylinder heads at a broaching speed between 150 and 175 fpm. The accuracy or tolerance obtained, using a horizontal broaching machine, is a function of (1) the rigidity of the fixture, (2) the built-in parallelism between the moving broach ram and the locating surface of the fixture, (3) the solidity with which the workpiece is clamped, and (4) the correct setting of the broaching tools.

A typical cylinder block provides the fourth example (Fig. 2). It is broached on a horizontal broach with finished surfaces similar to those obtained on the cylinder head. Depth of a surface like the bearing lock is usually held to ± 0.002 in., and the bearing lock width to ± 0.0005 in.

To hold these closer tolerances, the finishing section of inserts must be longer and, in general, smaller chips per tooth must be taken in the final stages than if a tolerance of ± 0.005 in. is required.

Cylindrical grinding is called upon daily to pro-

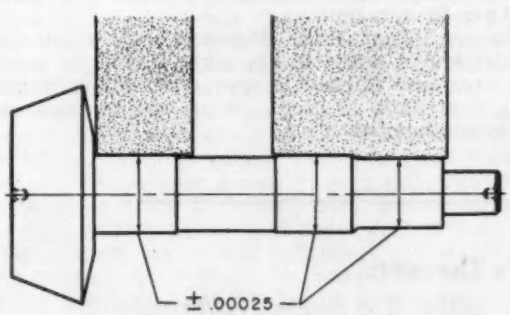


Fig. 3—Typical stem pinion with three diameters ground to tolerances of ± 0.00025 in.; 20 micro-in. finish, roundness and straightness tolerance 0.0002 in.

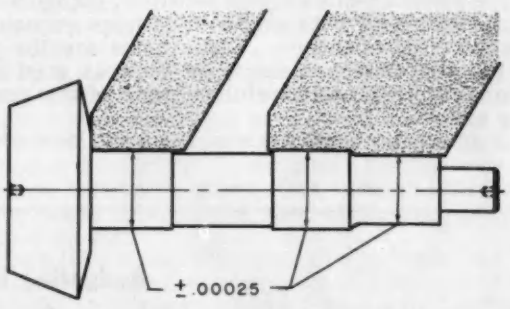


Fig. 4—Stem pinion as shown in Fig. 3, but requiring simultaneous grinding of three diameters and two shoulders to same tolerances as part shown in Fig. 3. Requires angular feed grinder.

duce closer tolerances than are normally expected from milling or broaching. Take, for instance, a stem pinion used in the automotive industry (Fig. 3). The requirements are for the three diameters to be ground by two wheels, properly spaced, to a tolerance of ±0.00025 in. The job also calls for a maximum of 20 micro-in. finish on these diameters, and they must be within 0.0002 in. for roundness and straightness. To illustrate the problem, let there be 0.015 to 0.018 in. stock removal after heat treatment.

To get the desired results, two grinding wheel cuts must be performed on such a part. On the rough grinding, 0.014 to 0.015 in. of stock should be removed per cut, and on the finish cut, 0.003 to 0.004 in. should be removed. Given this set of conditions and an automatic feed attachment on the grinder, one can expect approximately 100 pieces per 50-min hour per cut.

Now let us change the tolerances on the stem pinion such that diameters must be ±0.0001 in., the finish 10 micro-in., and requirements for roundness and straightness 0.00005 in., but with the same stock removal.

Working to these close tolerances creates an entirely different problem. It calls for careful consideration of the condition of the part before it is ground, the condition of the machine, the type of equipment used on the machine, and some incidental helps, if the desired results are to be achieved.

Requirements regarding the part are: (1) the manufacturer must exercise close quality control on the amount of stock removal, (2) depth and quality of centers is most important, (3) uniform heat-treatment must yield a straight part just prior to grinding. It may be necessary to deep-freeze the part to stabilize it before grinding.

The grinding machine must be in near-perfect condition. Temperature of hydraulic oil and coolant must be controlled closely, and it may be necessary to run the machine an hour before working. The machine must be carefully aligned and leveled, with headstock and footstock centers in excellent condition. Operation of the automatic cycle needs to be precise and tuned up to the nth degree. It might be necessary to use the machine in a temperature-controlled room. Finally, the temperature of the workpiece should be the same when it is being ground and when it is being checked.

Such limits require highly sensitive, highly stable gage equipment with graduations large enough to permit close operation. Other helps are the use of the best diamonds, the finest coolants, good lubricant filtering, and careful selection of the grinding wheels.

If all requirements are met, there will be a rough cut and a finish grinding cut, and production should approximate 60 pieces per 50-min hour per cut.

In these two cases, the closer tolerance cuts production by about 40%. It also means careful maintenance of equipment and some added features built into the grinding machine.

For the seventh example, the stem pinion case can be altered by requiring that the shoulder be ground at the same time as the diameters (Fig. 4).

Such an operation would require use of an angular feed grinder, with the same ±0.00025 in. tolerance as used before. This grinder should have an automatic flagging device to insure locating the workpiece endwise so that the shoulder will always clean up by the angular feed of the machine. The expected production would be 80 pieces per 50-min hour per cut, with a stock removal of 0.015 to 0.018 in. per diameter, with two cuts to get these limits.

One precaution applies to all these stem pinion jobs. When workpieces are ground involving profile diamond truing of the grinding wheel, a profile truing cam is essential and the cam should have a dimensional tolerance one-tenth that required on the part.

The eighth and last example is the automotive piston pin which must be made to very rigid tolerances. It must be held to 0.0002 in. for size, 0.0001 in. for roundness and straightness, and have a surface finish of between 2 and 3 micro-in. Generally speaking, the stock removed from these pins as they come from the turning operation to the green grinding could be removed in three or four operations, but more are required to obtain the finish and size without warping or checking.

A typical piston pin grinder line comprises a green grind removing from 0.008 to 0.010 in. before heat-treat, a heat-treating operation, a centerless grinding following heat-treat with 0.006 to 0.008 in. removed per pass, then four operations on No. 2 centerless grinders. The first machine removes from 0.004 to 0.005 in., the second from 0.002 to 0.003 in., the third machine from 0.002 to 0.003; and the fourth from 0.001 to 0.002 in.

The final finishing is done on two centerless lapping machines. The first removes 0.0002 to 0.0003 in. and the second perhaps 0.00005 in. to impart a high finish. Ordinarily, piston pins are fed through such a line of grinders and lappers, with conveyors in between, at the rate of 6 fpm. Since the average pin is about 3¼ in. long, the line will produce approximately 22 piston pins per minute or about 1100 per 50-min hour.

(Paper, "What Price Precision," on which this abridgment is based is available in full in multilith from SAE Special Publications; 485 Lexington Ave., New York 17, N.Y. Price: 35¢ to members; 60¢ to nonmembers.)

Budgeting Is People's Thoughts

■ *Budgeting is not figures and mathematics. Rather it is people. . . . People's thoughts, attitudes, and even emotions can make or break a budget system.*

—F. M. Hunt

Brake fluids with low boiling temperatures are potential highway killers. That's why SAE is recommending . . .

For Safe Motoring Use Only Heavy Duty 70R1 Brake Fluids

Based on paper by **B. E. Tiffany, W. R. Rodger, and F. J. Markey**

Ford Motor Co. Chrysler Corp. Moraine Products Division, GMC

. . . And on the work of the SAE Hydraulic Brake Fluid Subcommittee

MODERATE duty brake fluids are no longer considered safe for modern, high-speed vehicles, so the SAE has dropped the 70R2 brake fluid specification from the Handbook. It is hoped that this action will guide state legislatures in passing laws prohibiting the sale of brake fluids which do not meet the SAE specification of 300 F minimum boiling point. Seven states, Minnesota, Georgia, California, New Jersey, North Carolina, South Carolina, and Tennessee already forbid the sale of any brake fluid not meeting SAE 70R1 Heavy Duty specification.

Main reason for the action is today's vehicles are placing heavier demands than ever before on braking systems. Increased horsepower, automatic transmissions, smaller wheels, and smaller brakes all contribute to increasing the heat generated in brakes when stopping a car. For example, a 4000-lb car, when repeatedly stopped from high speeds, may generate fluid temperatures of 250 F or more from friction between brake linings and brake drums. This heat is transmitted to the wheel cylinders containing brake fluid. If this fluid has a low boiling point, the 250 F heat may vaporize some of the fluid and cause brake failure. This is especially true of mountain driving.

Because brake fluid is so vital to motoring safety, it must have other qualities to be acceptable. In addition to a high boiling point, it must remain fluid at low temperatures, have good lubricating qualities, be stable for a long time, and be compatible with rubber, metal, and other brake fluids.

Too, a good brake fluid will resist contamination with water. As little as 1% water will lower the boiling point at least 10 deg in a moderate duty brake fluid and may lower boiling point as much as 50 deg in a heavy-duty fluid.

Boiling point is also lowered if any moderate or substandard fluids are added to a heavy duty fluid. One automotive manufacturer found that even 10% of a substandard fluid will lower the boiling point of a heavy duty brake fluid from 340 F to 260 F. Twenty per cent of the substandard fluid lowered the boiling point to 230 F.

Back in 1945 SAE set up a committee of experienced brake and chemical engineers to prepare moderate-duty and heavy-duty brake fluid specifications. They came up with the 70R1 specification for heavy-duty service under severe passenger car and truck operating conditions and the 70R2 for moderate-duty service in passenger cars and light trucks. In the following decade these specifications were adopted and universally used by automotive engineers the world over and there was no need to make any major changes.

However, changing from open wheels to solid disc type, reducing wheel size, increasing width of rims and tires, placing brakes completely inside the wheel, lowering and streamlining the car bodies, adding fender skirts, improving heat resistance to brake linings, adopting automatic transmissions, and increasing the weight of the cars have increased the temperatures to which brake fluids are subjected.

When a brake fluid reaches its boiling point it starts to vaporize. Gas pockets or bubbles are formed in the top of the wheel cylinders or in the brake fluid lines. The vapor is compressible, so when you step on the brake pedal the pressure is absorbed instead of transmitted through the fluid to the brake shoe. Thus, the vehicle may not be stopped in time.

Brake failure may also occur due to vapor lock in master cylinders which may be caused by high temperatures completely unrelated to braking action. Master cylinders are usually mounted near the hot engine, power steering unit, automatic transmission, and exhaust pipes. It is not uncommon for brake fluids in the master cylinder of today's cars to reach 200 F. The brake fluid in the master cylinder is

under atmospheric pressure—not static pressure—so the fluid boils at the SAE indicated boiling point temperature.

Should the brake fluid boil in the master cylinder, brakes will fail without warning.

Mountain driving puts increased duty on brakes, power steering gears, automatic transmissions, rear axles, tires, and engines; thus, brake fluids are subjected to high temperatures in both wheel and master cylinders.

Phantom Failure

Another type of brake failure, known as phantom failure because it appears without warning, occurs in heavy traffic. Many repeated stops may not permit the brakes to cool between applications. The heat dissipated from the lining does not reach the fluid in the wheel cylinder until some time after the stop is completed. Thus the brakes fail when the car is standing still and the driver is unaware when he starts up again that he has no brakes. This type of failure is even more dangerous than partial failure while driving because in this case the driver has no warning and can take no precautionary actions.

Recently the SAE Joint Brake Fluid Temperature Subcommittee undertook a test survey to find out just what temperatures were prevalent in various types of vehicles on the road today.

It was found that:

1. Passenger cars and light trucks operating in today's congested traffic, through mountains and on expressways requiring many high-speed stops, develop brake fluid temperatures in wheel cylinders over 230 F.

2. Heavily loaded trucks making many fast stops or making fast trips through mountains, sometimes develop brake fluid temperatures over 300 F.

Having found sufficient evidence that the minimum boiling point of 230 F (called for in the 70 R2 specification) was becoming marginal, the SAE decided to drop it from the 1957 Handbook.

Further, seeing that the temperature of brake fluids in truck wheel cylinders exceeds the 300 F minimum boiling point of the 70R1 specification, the SAE has decided to start work on developing a much higher temperature brake fluid specification. (See page 86 for recent progress on this work.)

(This abridgment is based on paper "Trends in Brake Fluid Temperatures" and on the work of the SAE Hydraulic Brake Fluid Subcommittee.)

Scavenge Oil Filter . . .

. . . promises substantial increase in overall cleaning interval time and oil system protection for aircraft.

Based on paper by **Griffith May**, Screen Products, Inc.

NEW piston- and turbine-engine aircraft are being fitted with a filter in the scavenge oil line just ahead of the oil cooler.

The filter, which is of the composite element stack type, is shown in Fig. 1. Engine oil enters through the top of the flange face and surrounds the composite stack through which it passes. The filtered oil then enters the central core which guides it to the exit port.

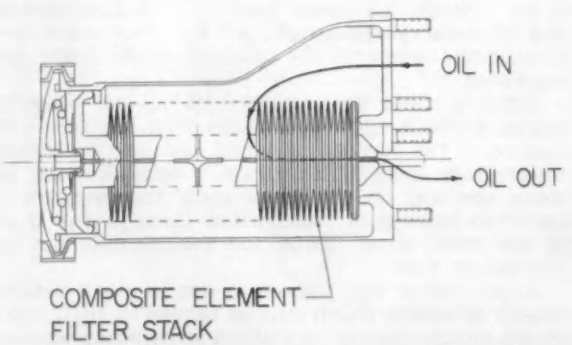


Fig. 1—Sectional view of scavenge oil filter of which composite element stack is an essential part. Mounted between engine oil-out port and oil cooler, it traps contaminants before reaching cooler, tank, or oil-in pump.

The composite element stack is made up of a number of individual symmetrical elements. Fig. 2 shows a section of one of these elements which consists of a formed aluminum central member, two screens adjacent to this central member, each screen having an individual inside diameter binder and an outside binder around the screens and spacer to complete the assembly. The aluminum spacer provides the exit passages from the screens and gives the screens their mechanical support. The screen inside diameter binders seal the edge of the screens and provide a load bridge to support the adjacent elements. The outside diameter eliminates fraying of the wire cloth edges, prevents leakage around the screens, and holds the assembly together.

The bypass operation is controlled by the conical spring (Fig. 1) mounted in the cover and bearing against the outer end of the stack. The outer end of the stack acts as a piston in the housing with downstream oil pressure between it and the cover. As the filter stack becomes loaded, the pressure drop increases and opposes the force of the spring. Sufficiently high pressure drop produces a movement of the stack away from the exit end, allowing oil to bypass between the stack and the housing support.

Location of the bypass near the inlet and outlet ports minimizes bypass flow over the stack so that the trapped contamination is not washed downstream. The large diameter of the housing support,

or valve seat, results in a high bypass flow area for a small deflection of the stack assembly.

Ease of Cleaning

The unit is disassembled for cleaning by removal of the single bolt clamp, the cover, and the stack assembly. The elements are removed from the stack core by application of a load sufficient to permit release of the crosspin. It is reassembled in a similar manner.

A scavenge oil filter has several advantages over the oil-in filter:

- Contamination is trapped immediately on leaving the engine, thus giving more protection to the cooler, tank, and oil-in pump.
- Lower rate of oil flow in the scavenge line results in lower pressure drop.
- The higher temperature of the oil produces less pressure drop.
- Greater flexibility in filter size, shape, and mounting methods.

The SP-160, as the scavenge filter is designated, is 9 3/16 in. long from flange face to cover by approximately 5½-in. maximum outside diameter. It weighs 10.5 lb dry. The unit contains a 3-in. OD × 7-in. long composite element stack capable of passing 350 lb per min engine oil flow with a pressure drop of 4 psi when clean.

Tests indicate the SP-160 will remove particles greater than 0.115 in. from TC18 engine lubricating oil for at least 100 operational hr with the pressure drop not exceeding 9 psi in cruise without maintenance attention. It is now being installed as original equipment on new DC-7 airplanes and is being retrofitted by many of the major commercial operators. A program to develop and test an external scavenge oil filter for a jet engine system has been completed recently with equally good results.

(Paper, "A Discussion of Some Recent Developments in Aircraft Engine Oil Filtration," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

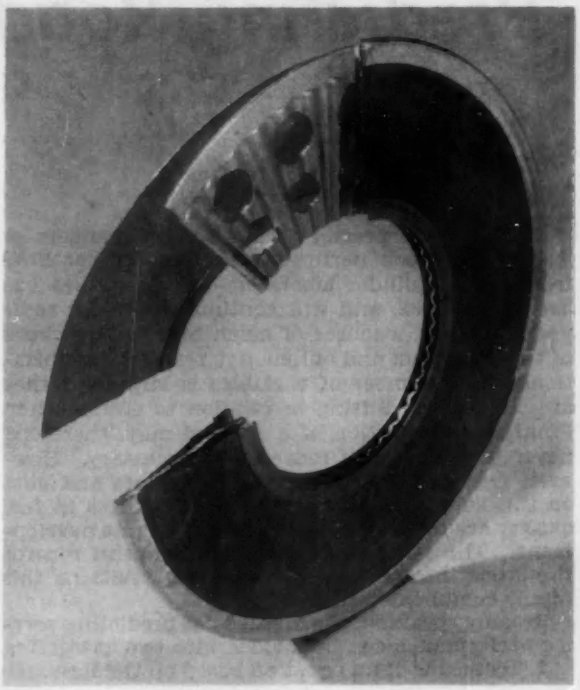


Fig. 2—Cross-section of individual element in composite element stack.

Business Aircraft . . .

. . . to be turbine powered. Fairchild has two models under development to meet coming demand for faster private transportation.

Based on paper by **Winfield H. Arata, Jr.**, Fairchild Aircraft Division, Fairchild Engine & Airplane Corp.

FAIRCHILD is working on two turbine-powered business aircraft. One is the turboprop-powered, 300-mph, F-27 (Friendship), available for purchase in 1958. The other is the turbojet-powered, 550-mph, M-185 (Fig. 1) scheduled to be ready for sale about two years later.

Both these models are high-wing, tricycle landing gear aircraft.

Fairchild believes turbine fuel will be generally available by the time these transports need it. At present only the military and such airlines as Capital Airlines are using it, but when new airliners like the DC-8 and 707 become operational, fuel requirements will climb.

Turbine fuel for airline use alone by 1960 will be equivalent to the entire civil use of 100-octane aviation gasoline, according to estimates. By 1961, turbine fuel needs will be equal to all current aviation gasoline requirements. For this reason, the fuel pipeline for the business-owned turbine transport will be in readiness.

(Paper, "The Development of Business Transport Aircraft," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



Fig. 1—Mockup of Fairchild M-185 turbojet-powered business transport to be ready about 1960.

Predicting Road Octanes Is Long

THE ability to predict "true" octane numbers or road antiknock performance of motor gasolines from single-cylinder laboratory-engine ratings has been since 1932, and will continue to be for some years to come, a source of much investigative work in the petroleum and automotive research organizations. The number of variables is large and they are constantly shifting in relation to one another. Final standardization of a method may, therefore, never be achieved, if indeed it is necessary. However, frequent interchange of viewpoints and data on this subject is necessary if the advances in fuel quality are to be made full use of by engine development. The symposium described herewith records the latest interchange of views and results on this highly complicated subject.

Broadly speaking, the methods of predicting service performance can be divided into two categories.

1. By means of an equation based on the Research and Motor ratings of the fuel with or without a factor.

2. With a single-cylinder laboratory engine that duplicates, as closely as possible, the combustion environment (end gas temperature, density, and time of burning) of the full-scale engine.

Prediction by Equation

Corner said that good correlation can be obtained between road octane ratings and their Research and Motor octane numbers for conventionally made, full-volatility gasolines with the following equation:

Road ON $= m_1$ Research ON $+ m_2$ Motor ON $+ C$

The coefficients m_1 and m_2 are constant in any given car at any given speed at which knock occurs. They are equal to the change in road ON per unit increase in Research and Motor ON's, respectively. C, an integration constant, is a correction factor that must be added to or subtracted from m_1Re-

THIS article is based on the following papers and discussions:

Papers:

- "Approach to Obtaining Road Octane Ratings in Single-Cylinder Engine," by **E. M. Barber, H. I. Wilson, and T. H. Randall,** Texas Co.
- "Octanes—from Laboratory to Road," by **E. S. Corner,** Esso Research & Engineering Co.
- "Fuel Antiknock Performance in High-Compression Engines," by **C. J. Domke, N. D. Esau, D. S. Gray, and H. R. Taliaferro,** Standard Oil Co. (Ind.)

The papers only are available from SAE Special Publications Department, 485 Lexington Ave., New York 17, New York. Price: 35¢ each to members, 60¢ to nonmembers.

Discussions of these papers by:

- **F. C. Burk,** Atlantic Refining Co.
- **John D. Caplan,** Research Staff, General Motors Corp.
- **Otto Enoch,** Ford Motor Co.
- **F. T. Finnigan,** Pure Oil Co.
- **L. W. Griffith,** Shell Oil Co.
- **H. E. Hesselberg,** Ethyl Corp.
- **J. R. Landis,** Chevrolet Motor Division, GMC
- **E. J. McLaughlin,** Calif. Research Corp.
- **W. E. Morris,** E. I. du Pont de Nemours & Co.
- Secretary's report of oral discussion, by **J. E. Taylor,** Gulf Research & Development Co.

Sought Goal

search ON + m_2Motor ON to give the correct numerical value of road octane number.

Morris reported on a similar approach. He correlated laboratory and road octane numbers for gasolines of a range of sensitivities that had been bought at service stations. The form of his equation is:

$$\text{Road ON} = a + B\ [n\text{Research ON} + (1-n)\ \text{Motor ON}]$$
$$= 21.3 + 0.827[0.3\text{Research ON} + 0.7\text{Motor ON}]$$

The constant a is identical with Corner's C, $Bn = m_1$, and $B(1-n) = m_2$. Corner determined $m_1 + m_2$ by plotting road against Research ON's at constant sensitivity. Morris and associates followed a different procedure. They correlated road with different combinations of Research and Motor ON's at increments of $0.1n$. By trial and error, using statistical calculations, they determined the combination giving the highest correlation coefficient. Then they calculated the constants a and B of the equation.

Fuel Composition Factor in Equation

Domke et al. described a method of determining road ratings of high compression ratio engines from Research octane number and Motor octane number but using a special factor for hydrocarbon composition. Fig. 1 shows how this has been worked out for an experimental V-8 engine.

Hydrocarbon composition is one of the ingredients with this method because these investigators have found that Research and Motor ON's are no longer fully adequate to describe fuel antiknock performance, as shown in Fig. 2.

This point was disputed by Corner, who claimed that fuels of different hydrocarbon type but the same Research and Motor ON's have the same road rating. He based his contention on the excellent correlations he obtained with his equation (given earlier), and other studies. These studies have covered Uniontown and Borderline ratings of gasolines of conventional volatility made up with a variety of different refinery streams.

Thus, the ranges of hydrocarbon type evaluated in one particular study covered: 0–60 for aromatics, 1–100 for olefins, and 0–96 for saturates.

The small variations in road performance obtained with varying composition are illustrated in Table 1. The road octane numbers were in line with expectations based on Research and Motor ON only.

A comparison of nonselective polymer with hydroformate indicated a slight advantage for the hydro-

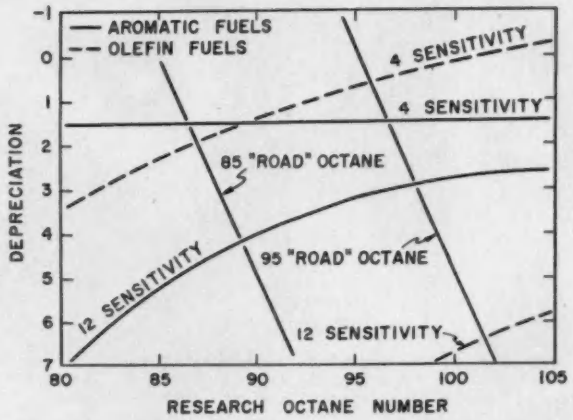


Fig. 1—Fuel quality and composition versus performance for experimental V-8 engine of 287 cu in. displacement operated at 2500 rpm. Lines of constant "road" octane number assigned by engine are superimposed.

Engine requiring 95-octane primary reference fuel would be satisfied by olefinic fuel of 4 sensitivity and 95.5 Research ON. At 12 sensitivity, fuel of 101.5 Research ON would be required. This engine would also be satisfied by aromatic fuels of 96.5 Research with 4 sensitivity or 98 Research with 12 sensitivity. Thus, at 12-sensitivity level, road-octane advantage of aromatic fuel would be difference between 101.5 and 98, or 3.5 units over olefinic fuel, and all these fuels would give same power output as limited by antiknock quality. (From Domke et al.)

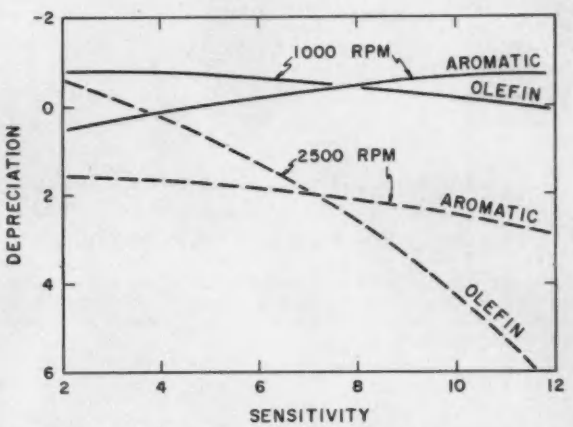


Fig. 2—Effect of engine speed for 100-octane fuels.

Note that although all fuels depreciated with increased engine speed, aromatics were affected far less than olefinic blends. They offered significant advantage over olefinic blends in reduced depreciation (Research ON—road ON) at high sensitivity and high engine speed. (From Domke et al.)

Table 1—Road Antiknock Performance of Fuels Varying in Hydrocarbon Type (From Corner)

	Fuel A	Fuel B
Aromatics, volume %	18	55
Olefins, volume %	33	1
Research ON	95.2	95.5
Motor ON	83.2	84.1
Road ON (16 car average)	94.4	94.8

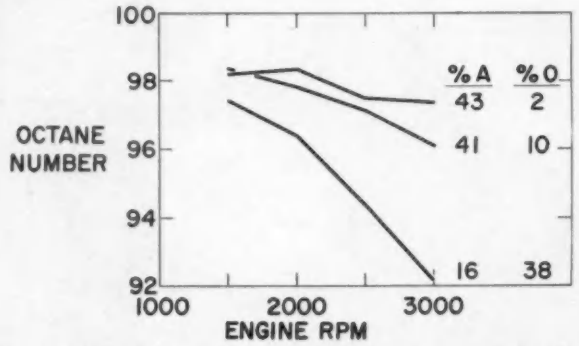


Fig. 3—Modified Borderline ratings, averaged for car make A with 10/1 compression ratio V-8 engine and car make B with 9/1 compression ratio V-8 engine (all fuels contain 3 ml tel). (From Hesselberg.)

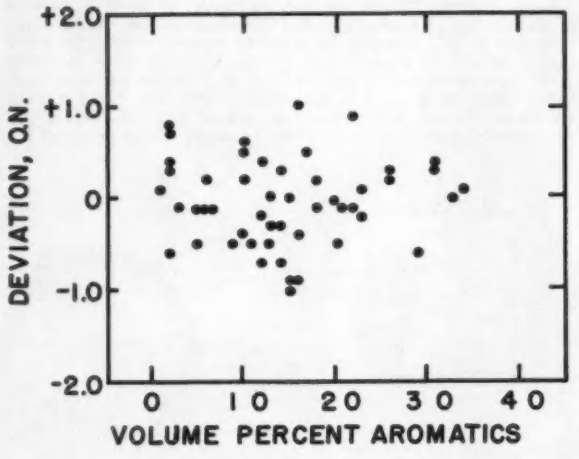


Fig. 4—Deviation of actual from predicted road octane number versus per cent aromatics. Based on Modified Uniontown road ratings of 50 premium service station gasolines in 1955 car that required premium gasoline. (From Morris.)

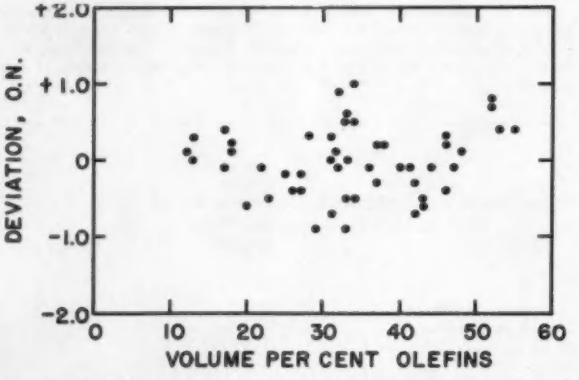


Fig. 5—Deviation of actual from predicted road octane number versus per cent olefins. Based on Modified Uniontown road ratings of 50 premium service station gasolines in 1955 car that required premium gasoline. (From Morris.)

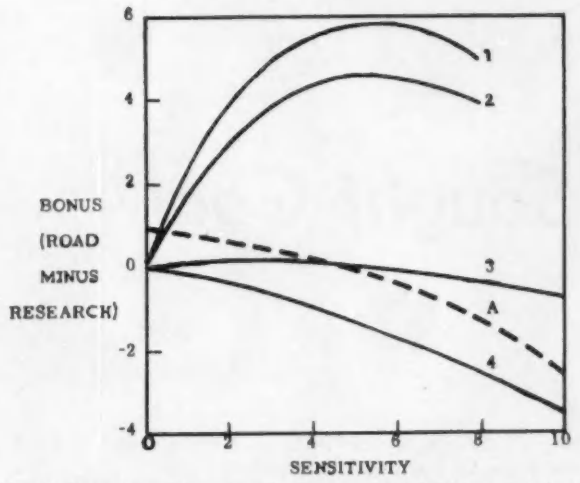


Fig. 6—Appreciation characteristics versus sensitivity for several fuel blending components in isooctane-heptane base (curves 1, 2, 3, and 4). Curve A is for average commercial fuels. (From Griffith.)

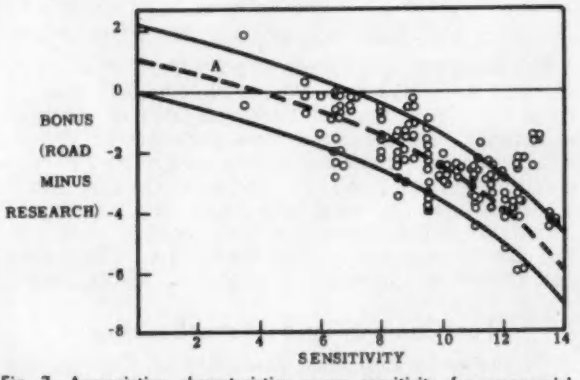
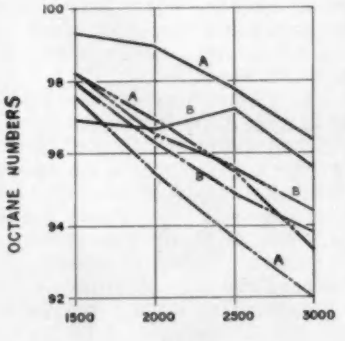


Fig. 7—Appreciation characteristics versus sensitivity for commercial high-antiknock fuels being used in 1956 cars. Solid heavy lines define band of correlation between bonus and sensitivity established in 1952 from all data available at that time. Curve A is for average commercial fuels. (From Griffith.)



A 106° CARB. AIR —— 35% ISOMERATE PLUS CAT. REFORMATE
B 57° CARB. AIR ---- 46.5% F.C.C. PLUS CAT. REFORMATE
—— MIXTURE OF F.C.C. PLUS STRAIGHT RUN

Fig. 8—Road octane values for experimental blends of nominal 97.5 Research octane number. (From Finnigan.)

formate at 2500 rpm in one group of low-priced cars (group A) but failed to show any advantages in an expensive-car group (group B). The data are summarized in Table 2.

Corner pointed out that the effect of variations in hydrocarbon type studied in 10/1 compression ratio engines may not be extensive enough to draw firm conclusions, although olefin concentration was varied over 6–48% and aromatic concentration over 13–30%. He realized that in the fuels of extremely high aromatic content, such as are likely for the future, hydrocarbon-type effects could exist, and also, possibly, for engines of higher compression ratio.

Hesselberg, on the other hand, agreed with Domke that there is more to predicting road performance than laboratory-determined Research and Motor octane numbers. Fig. 3 (from his discussion) shows, for example, the varying road performance of three full-boiling fuels of different hydrocarbon composition, but of about equal Research octane number (98.0) and of about equal Motor octane number (86.4 to 88.5).

This shows that the better fuel from a road performance standpoint shows only about 1 ON depreciation as speed is increased from 1500 to 3000 rpm. The second fuel depreciated by only about 2 ON, while the third depreciated markedly as speed increased, ending up about 5 ON below the rating of the first fuel. Hesselberg feels that the 5-ON difference in road performance at the 3000-rpm speed results from differences in hydrocarbon composition as well as the 2-ON difference in sensitivity that existed between the two fuels.

Morris went even further. He felt that it isn't even possible to explain the behavior of unusual fuels merely on the basis of the four hydrocarbon types: aromatics, olefins, paraffins, and naphthenes, when they are made from refinery components. In Fig. 4, for example he compares deviations from the laboratory versus road correlation with aromatic content. Note that the deviation from the best laboratory versus road correlation had no relationship to per cent aromatics. As shown in Fig. 5, the deviation also bore no relationship to per cent olefins. Similar results were obtained in a second car using for test premium gasolines and two cars using regular gasolines. These deviations, he feels, must be related to hydrocarbon composition, but apparently the percentages of the four hydrocarbon types do not define the hydrocarbon composition adequately.

Further light on this matter came from Burk, whose studies also show that fuel composition must be identified by more than just hydrocarbon type. There is, he explained, a wide range of octane levels for hydrocarbons in each of these types, with n heptane and isooctane as classic examples in the paraffin series. For commercial gasolines, straight-run components vary in octane level, he added, from say 50 to 75 Research. Alkylate, with Research ratings exceeding 100, are also typical of the paraffinic series of hydrocarbons.

He illustrated this further with Table 3, which shows three commercial gasolines all having the same Research ON, essentially the same sensitivity, but widely different road octane values. Fuel 1, which gave the lowest road value, contained the minimum of paraffinic components. These particular components were low-octane straight-run stocks and the Research octane level was achieved by using high percentages of cracked and reformed stocks of the aromatic type. Fuel 2, having the highest road ON, contained a maximum percentage of straight-run or paraffinic stocks, with high-octane alkylate components predominating. Fuel 3, had a composition intermediate between Nos. 1 and 2, although no alkylate was used in it. In these cases, he concluded, the kind of paraffinic or aromatic components must be known to help identify fuel antiknock quality.

The extent to which fuel composition can influence road performance was also shown by Griffith in Fig. 6. Curve A shows the depreciation with sensitivity obtained for average commercial fuels. Curve 1 shows about the maximum bonus that can be obtained (there is a difference of about 7 ON). Other blending materials fall between these two extremes or below the average commercial fuel. With this fuel you do not get the extremes of bonus shown in this figure. The average condition is shown in Fig. 7. This chart indicates that for a large number of commercial fuels sensitivity will define road depreciation or bonus. As indicated by the points that fall well outside this average band, however, certain fuels show considerably better (or poorer) perform-

Table 2—Road Antiknock Performance of Catalytic Reformate and Nonselective Polymer (From Corner)

	Hydroformate Fuel	Polymer Fuel
Aromatics, volume %	55	0
Olefins, volume %	1	100
Research ON	95.5	96.3
Motor ON	84.1	80.8

Road ON Advantage for Hydroformate	Car Group A		Car Group B	
	Actual	Predicted[a]	Actual	Predicted[a]
1500 Rpm	3.9	3.4	3.1	3.6
2500 Rpm	6.9	5.3	4.1	4.2

[a] Using equations derived from commercial fuel ratings.

Table 3—Fuels of Same Research Octane Number and Sensitivity Have Different Road Octane Numbers (From Burk)

	Research Octane Number	Motor Octane Number	Sensitivity	Road Octane Number	Tel Content	Hydrocarbon Type: Straight-Run or Paraffinic	Hydrocarbon Type: All Others: Naphthenic, Olefinic, and Aromatic
Fuel No. 1	94.0	86.8	7.2	91.6	1.0	20	80
Fuel No. 2	94.0	87.8	6.2	94.1	3.0	45	55
Fuel No. 3	94.0	86.0	8.0	92.7	2.3	30	70

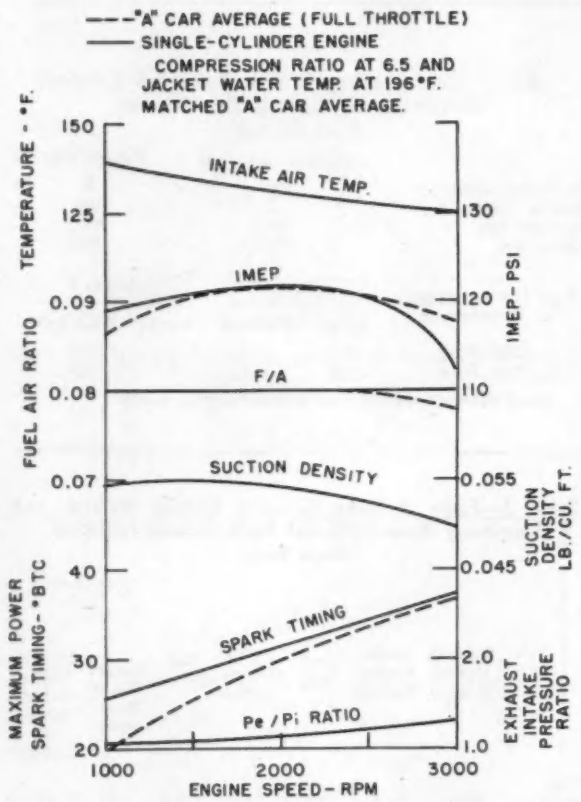


Fig. 9—Comparative operating conditions of automobile and single-cylinder engines. Single or common curve shows exact correspondence, single-cylinder engine being arbitrarily controlled to duplicate automotive values. Automobile data are average of four cars, each of which, individually, was reasonably close to 4-car average. (From Barber et al.)

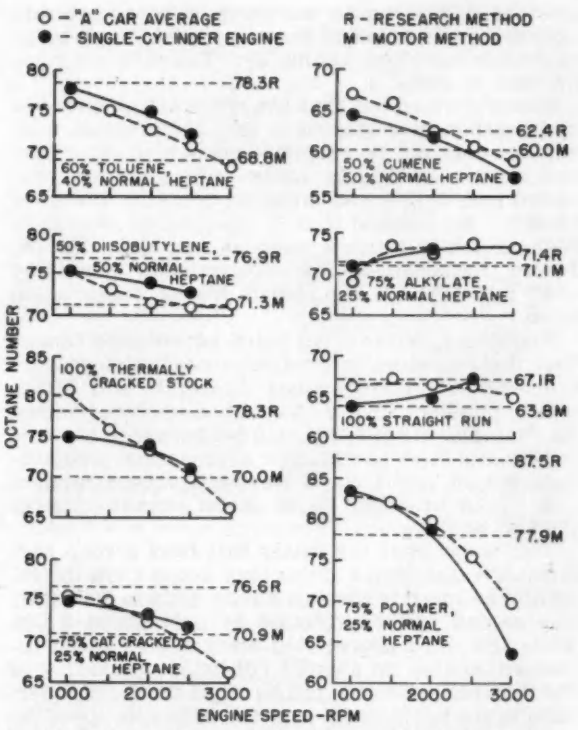


Fig. 11—Octane ratings obtained with domed-head single-cylinder engine compared with average Borderline ratings obtained with car A. Note good agreement between single-cylinder engine and car road octane ratings. (From Barber et al.)

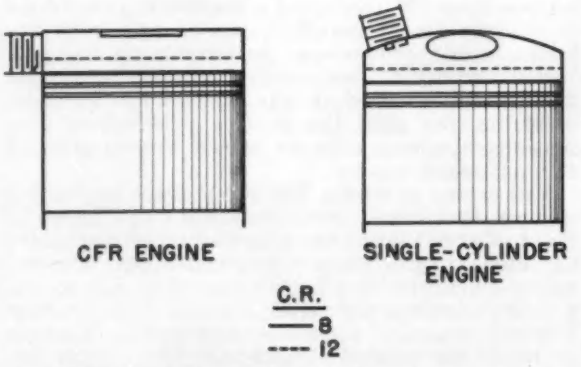


Fig. 10—Domed combustion chamber (right) was chosen to give more nearly central location of spark plug, which, in turn, gives reasonably short burning path and, with coning, creates mild "squish" turbulence. Originally built for fixed compression ratio operation, engine was later adapted to operate with variable compression ratio. (From Barber et al.)

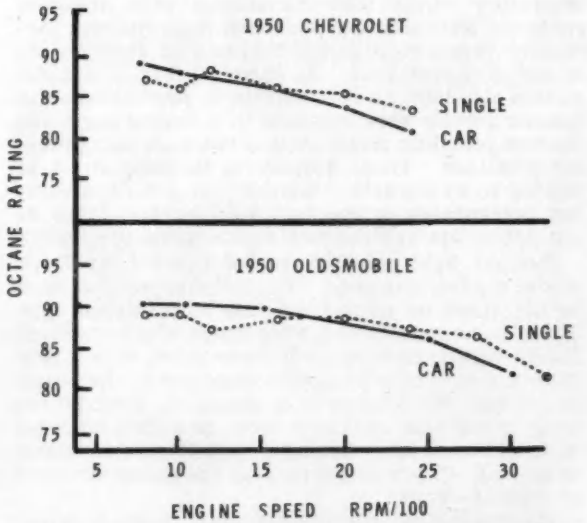


Fig. 12—Comparison of Modified Borderline ratings of same fuel in both single-cylinder engines and test cars. These data indicate degree of duplication of fuel ratings that can be obtained by this approach. (From Caplan.)

ance than would be expected from their sensitivities. This again emphasizes Domke's point of Fig. 2 that more than a sensitivity specification is necessary to define the bonus performance of fuels.

New Laboratory Engine Methods

Another way to predict road rating is by duplicating the combustion environment of the full-scale engine in the laboratory engine. The idea is to produce in the single-cylinder lab engine the same end gas temperature, density, and time of burning as in the full-scale engine.

The effect of air temperature on fuel ratings and its relation to hydrocarbon composition are shown in Fig. 8, by Finnigan. Note that at the lower temperatures, the aromatic-olefinic blends apparently increase in road response and at the higher temperatures the paraffin-aromatic blend is superior.

Barber et al., for example, proposed a method of rating fuels, based on a single knock rating technique, but with certain modifications to the ASTM engine and procedures:

1. Engine operating conditions (cylinder charge density, intake air temperature, mixture strength, and the like) are selected to produce typical automotive values of compression density, temperature, and mixture strength. (See Fig. 9.)
2. Combustion-chamber design is modified to give combustion duration, length of burning path, and surface/volume ratio comparable to that found in actual automobile engines. (See Figs. 10 and 11.)

Successful application of this same idea was reported by Caplan, who has tried duplicating in single-cylinder engines the combustion environment in both Chevrolet and Oldsmobile engines, as shown in Fig. 12.

This basic principle is being studied by ASTM Research Division I of Committee D-2, which has the responsibility for improving knock test methods.

So far, however, according to Burk, no method of actually carrying it out has been devised because we do not yet have the instruments to measure these conditions exactly in the combustion chamber when knocking occurs. For this reason the ASTM committee and others are studying practical means of at least approaching this ideal by varying the operating conditions and changing the design of the combustion chamber.

Others were somewhat dubious about getting a true road octane number from a single laboratory rating method. They feel that it is generally more satisfactory to have two laboratory test procedures (preferably using the same basic engine), which differ widely in the severity of their operating conditions. If such test procedures are properly worked out, McLaughlin felt, they will provide two ratings that represent the best and poorest performance of the test fuel and also a measure of fuel sensitivity. He considered the use of two test procedures also greatly minimizes the amount of test method modification that will be required as new production engines having different degrees of severity become available. The reason is that the correlation with the road ratings is not one value but rather the appropriate interpolation between the two extreme laboratory values. Thus, McLaughlin would prefer to see the test engine and data provided by Barber and associates used for the development of two test procedures that will bracket road ratings rather than one test procedure designed to match the road rating.

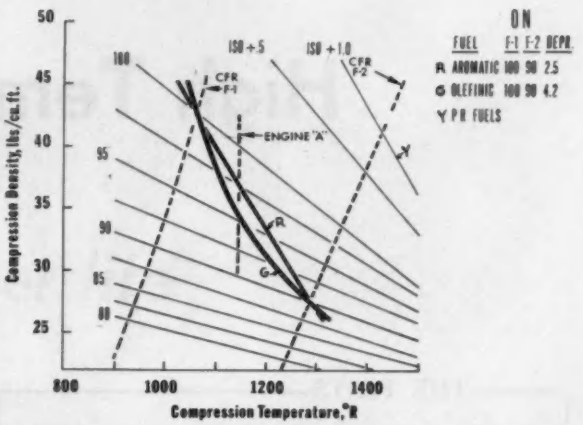


Fig. 13—Data from Fig. 2 plotted on compression density versus compression temperature graph. (From Enoch.)

Similar ideas were expressed by Hesselberg, who thought that the single rating would involve relatively frequent changes in both engine and operating variables as automotive engines and transmission designs progress. In reply to these comments, Barber said that such frequent changes would not be required because the changes in car ratings from year to year are too small.

In trying to get a clearer picture of fuel behavior, Enoch picked out from Fig. 2 a couple of aromatic and olefinic fuels having 100 Research and 90 Motor ratings in engine A at 2500 rpm and plotted their data in the diagram shown as Fig. 13. Here, fuel antiknock value and engine antiknock requirement are expressed in terms of compression end density and compression end temperature as substitutes for end gas density and temperature. Detonation limits of a fuel are shown in this diagram, along a curve characteristic for this fuel of density versus temperature. Primary reference fuels thus obtained are also shown. Engine density-temperature operating conditions are shown for the Research (F-1) and Motor (F-2) methods by dotted diagonal lines and for engine A by the dotted vertical line. Intersection of the Research line with the 100-octane reference fuel curve, of the Motor line with the 90-octane reference fuel curve, and of engine A line with the 97.5- and 96-octane reference fuel curves represent three points on the density-temperature curves for the aromatic and olefinic fuels, respectively, which can be drawn through these points. These curves, if true, permit us to follow the depreciation trends of the fuels over the total range of possible engine conditions. For instance, they show that depreciation reversals occur beyond the Research and Motor lines. This plot, he feels, is a good illustration of where the density-temperature rating method can come in handy if it can be developed to a satisfactory degree of accuracy.

High Temperatures Cause

—but coated steels

THE TESTS

Metallographic, field, and laboratory tests provided the data on which this article on truck mufflers is based.

Samples from a number of failed mufflers and from different locations in the same muffler were examined metallographically in an attempt to determine the cause of failure. These metallographic tests indicated a definite need for information as to the temperatures encountered in mufflers under actual service conditions.

Accordingly, two standard mufflers were specially instrumented and, after testing, installed in trucks chosen at random from over-the-road fleets. The temperatures obtained in the mufflers were recorded under the actual service conditions encountered by the trucks.

After obtaining this information, a laboratory test rig was constructed and specimens made of various materials were subjected to conditions similar to those encountered in actual service. After exposure to these high-temperature conditions the specimens were tested for changes in tensile strength and a portion of them were examined metallographically.

TESTS performed on truck mufflers indicate that:

1. High temperatures are primarily responsible for muffler failure.
2. Either lead or sulfur in a fuel tends to decrease the service life of a muffler.
3. Coated mild steels offer definite promise of extending either service life or permissible temperatures.

Field tests of truck mufflers operating under actual service conditions reveal that the primary factor in muffler failure is high temperature. The gas temperature in the muffler is usually nearly as high as the gas temperature in the intake manifold, and sometimes even higher.

How high the muffler temperature goes appears to depend only on the throttle opening and to be comparatively independent of vehicle speed and altitude. Typical maximum gas temperatures are 1220 F for the diesel engine and 1430 F for the gasoline engine. Typical maximum metal temperatures inside the muffler are 1180 F when used on the diesel engine and 1360 F when used on the gasoline engine.

The high temperatures common to the muffler, and especially when these temperatures are greater than the temperatures in the intake manifold, suggest that appreciable combustion oftentimes takes place in the muffler, particularly under high-engine-load conditions. The fact that we used unshielded thermocouples for our temperature measurements may possibly explain why higher temperatures were recorded in the muffler, at times, than at the inlet. On the other hand, the lack of relationship between vehicle speed (and thus external cooling) and muffler temperature indicates that some heat release is taking place in the muffler.

Laboratory tests performed on the muffler material (mild steel) revealed that muffler operation falls within a temperature range such that any additional small increase in temperature will produce a marked decrease in muffler life (Fig. 1). Consequently, the higher temperatures peculiar to the muffler under high-engine-load conditions probably are the primary cause of accelerated failure of the muffler.

In addition to the effect of temperature on muffler life, the addition of either lead or sulfur to a

Muffler Failure—

give promise of longer life

Based on paper by **W. Chow,** Sparton Automotive Co.
C. E. Nelson, Nelson Muffler Co.
P. S. Myers, P. C. Rosenthal, and O. A. Uyehara, University of Wisconsin

fuel tends to decrease the service life of a muffler. Fig. 2 shows the effect of sulfur and lead additions to a fuel on enameling steel specimens coated with an A19 ceramic material. Similar results were obtained for enameling steel coated with a base material. The test results for aluminized steel were also similar except for the lead and sulfur curves being interchanged.

If operating temperatures are too high for mild steel the obvious two remedies insofar as the muffler is concerned are either to reduce the operating temperature by better engine or muffler design or to use a better muffler material. Since it is difficult, if not impossible, to effect an appreciable temperature reduction by design, we chose to investigate possible muffler materials. The materials tested were primarily coated mild steels and stainless steels.

The results of our tests indicate that if the coating of a coated steel diffuses into the steel it increases the life of the material at any particular temperature. For example, metallographic examinations indicated that both aluminum coating and chromium plating diffused into mild steel but that silicone and aluminum paints did not. Correspondingly, temperature-time test results reveal that aluminum and chromium coatings increase the life of the material.

Although 405 stainless steel coated with A19 ceramic material appeared to offer the maximum in muffler life of all the materials tested, coated mild steel showed the most promise of longer muffler life at a reasonable cost under high temperature conditions.

(Paper, "Temperature-Strength-Time Relationships in Mufflers and for Truck Muffler Materials," on which this abridgment is based, is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

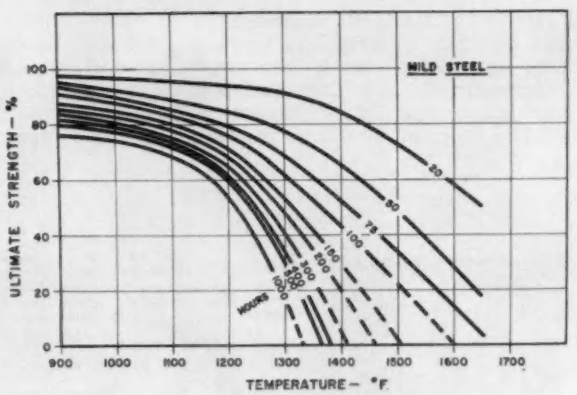


Fig. 1—Small increases in operating temperature greatly reduce the ultimate strength and, therefore, the service life of a mild steel muffler.

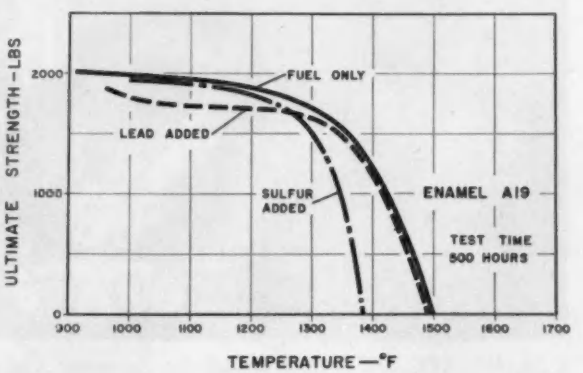


Fig. 2—Sulfur and lead added to a fuel also tend to decrease the service life of a muffler.

Rear-Engined Car

Back in Spotlight at Passenger-Car

THE rear-engined passenger car and its familiar design problems came back for 1957 inspection at the Passenger Car, Body, and Materials Meeting in Detroit, March 5–7.

Recent American successes of the German Volkswagen, Citroen CV, and other small European rear-engined cars foreshadowed one conclusion of engineers at these sessions: This construction is now practical for small light cars. No one, in fact, was heard to contradict Fernand Picard, Renault's engineering head, when he said (in a paper read by Henry Brownback in Picard's absence):

"For piston displacements of less than 1500 cc, the rear-engined car will not only maintain its present position, but will improve it."

But we are not yet close enough to overcoming traditional weight distribution disadvantages to forecast rear engines on American cars.

Some of the things necessary to make rear engines attractive on American-sized cars have begun to happen, it is admitted. The smaller and lighter electrical units, hydraulic pumps, and fuel-supply systems already available, for example, would help on a rear-engined design. And styling the transitional body shape, which would characterize the first American job (if and when), offers few difficulties.



L. H. NAGLER, SAE Vice-President for Passenger Car Activity (left), with C. C. Dybvig, Detroit Section Chairman. Dybvig welcomed the Meeting guests at the dinner.

Lighter Engines Needed

Much more important developments, however, are needed—lighter engines and transmissions, for example—to permit successful application of a rear-engined design to an American-sized car.

One designer put it this way:

"Much lighter powerplants will be required to make a future standard-sized rear-engined passenger car a practical possibility. The transmission designer, too, will have to do his part in weight reduction.

"What kind of fore-and-aft weight distribution can be achieved for a given number of dollars, in other words, will still finally determine the practicability of an American-sized rear-engined design."

Independent suspension in the rear was said to be "a natural for rear-engined cars" and also "the one remaining major change to improve the ride on standard

Meeting



TOASTMASTER V. A. Crosby (right) introduced **SAE President W. Paul Eddy** (left) to a capacity dinner audience on the closing evening of the Meeting. Eddy spoke briefly and presented to **M. A. Thorne** a plaque in appreciation of Thorne's accomplishments as general chairman of the Meeting.

models." It's coming—in volume, the insiders say, now that the ice has been broken.

Suspension Systems Analyzed

Modern suspension systems, incorporating such devices as automatic compensation for lead changes, were spotted as another help toward rear-engined design feasibility. They could help toward bettering the 40/60 maximum extreme car weight distribution needed to make the rear-engine mounting practical.

Suspension developments to better current front-engined car rides were in the spotlight, however.

General Motors engineers revealed, among other things, why they bypassed the double-convolution bellows in applying air springs to passenger cars, despite this construction's proven success on GM buses.

One reason, they said, is that at normal height the double-convolution bellows construction would have a load-carrying capacity of 2000 lb at 65 lb per sq in. operating pressure and might be used as a passenger car front spring, if applied through a wishbone linkage. Obtaining the necessary spring rate, however, would involve using an additional 700 cu in. reservoir.

For long-stroke, direct-acting rear-axle applications, they pointed out, the picture becomes more critical. A reduction in diameter brings load to something like 1200 lb at 60 lb operating pressure. The stroke is reduced an unsatisfactory amount. And getting a longer stroke by increasing the number of convolutions would result in instability. So the only answer would be to guide the bellows in some fashion.

"In brief," they concluded, "with the double-convolution bellows, undesirable factors are present to a greater degree than we felt could be tolerated."

Chrysler engineers detailed their progress toward nine specific goals in improvement of automobile ride . . . one of which was to reduce "braking dip" and "acceleration squat." They reported a 65% reduction of the amount which the suspension goes into jounce during acceleration. The reduction is due, they said, to the inclined upper control arms which provide a lifting component on the front suspension to offset the weight lift. Also, using a highly unsymmetrical leaf-spring rear suspension, the rise during deceleration of the rear of the car has been reduced by 40%. During acceleration the rear, instead of squatting, actually rises slightly.

Rear Axle Possibilities

Designers got satisfaction from assurances given by axle men that the capacity of present passenger-



GENERAL CHAIRMAN M. A. Thorne (right) and **Dr. R. C. S. Young,** who was the chief speaker at the dinner. Young talked on "Living the Full Life". . . . Thorne set the theme of the Meeting in a brief talk titled "More Progress" at the opening session.

Thorne said in part: "Whether or not more progress comes out of this meeting for you and for me depends chiefly on the degree to which our minds participate actively with the speakers. In my own experience, the results of active listening have far outstripped those of passive listening.

"This has been the case whether I have participated in the discussion or not . . . because any active listener is discussing the speaker's idea with himself all through the session.

"To the active listener, this meeting is a typical SAE opportunity to make more progress."

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car rear axles can be increased still further without increasing size. Then they curbed their hopes a little when they heard the qualification: ". . . when greater anti-wear and anti-score lubricants are available."

But reports of further progress toward just such lubricants were also indicated in informal exchanges. There are some who feel that dry or solid lubricants may eventually be used extensively. Properly applied, some axle men feel, molybdenum disulfide and other materials may be important in providing needed anti-wear and anti-score properties—especially under heavy-load, high-temperature service. Others say liquid petroleum lubricants already are available to meet more than existing needs. Price as well as performance will affect any trends which may result from widespread current laboratory experimentation with the dry lubricants throughout the vehicle industry.

Improved facilities for testing rear-axle noise were urged by car engineers who feel that none of the types currently in use yield "a completely satisfactory analysis of the noise as encountered in the automobile." It was admitted that "the only known method of determining whether an axle will be satisfactory under a particular vehicle from a noise standpoint is to check the unit in the particular vehicle.

American engineers said that the noise level of gears in European cars is admittedly higher than that of American cars—chiefly because the European public will accept a higher noise level than will the American. Only advantage American designers have is that quantity production provides long experience with a particular design and permits gradual modification and improvement throughout the life of the design.

Materials and Finishes Puzzlers

Most designers agree they are hard put to maintain a current, working knowledge of the constantly growing varieties of new materials and finishes being made available.

"I just begin to feel at home with acrylics, butyrates, and styrenes," one of the said, "when—before you could say 'anodic oxidation'—I'm being introduced to a string of newcomers."

Evidence that this engineer and his fellows are trying hard for that working knowledge is the deep interest shown at this meeting. Well-attended sessions were fruitful of information on new finishes, new chemically-created materials . . . and on how to use vacuum melted metals in modern design.

Absence of a satisfactory nondestructive method of testing for inclusions, some engineers say, is retarding design use of vacuum-melted metals. They are hoping for development of such a method, however, because, as designers, they like the ductility and greater resistance to impact offered by these metals. They like the greater resistance to fatigue failure, too.

Even Smaller Cars Abroad

European engineers at the meeting said the Suez oil crisis, added to existing inflation and upward tax trends, is creating an even greater trend abroad toward smaller and smaller cars that go very easy on oil and gas.

CEP
COOPERATIVE ENGINEERING PROGRAM NEWS

SAE Sells Ten Millionth AMS

Seventeen Years After Inception

SAE's TEN MILLIONTH AERONAUTICAL MATERIAL SPECIFICATION was sold on Feb. 26, 1957, only 17 years after AMSs were first made available by the Society. The buyer was David E. Waite of Associated Spring Corp.'s Wallace Barnes Co. Division. Presence of SAE President W. Paul Eddy marked the importance of the occasion, symbolic of the major contribution by aeronautical engineers to the industry. Also on hand was Eve Gorvetzian, SAE staff coordinator of AMS publications.

Working under the auspices of the Aeronautics Committee of SAE's Technical Board, more than 300 of the industry's finest engineers are currently active in the development of SAE Aeronautical Material Specifications. Since 1940, the entire AMS project has been guided by John B. Johnson, chief scientist, Aeronautical Research Laboratory, Wright Air Development Center.

The last 17 years have been marked by the development of additional AMSs and increased usage throughout industry and government . . . at a savings to both.

AMSs pass the ten million sales mark as demonstrated values cut across all elements of the aircraft business. Special advantages are provided for each segment of the industry. The following expressions from both civilian and military engineering users emphasize across-the-board benefits derived from AMS.

- AMSs are acceptable to the military, but are written by industry's engineers. They are a realistic expression of engineering excellence, manufacturing adaptability, and commercial availability.

- A quality-conscious industry is assured of quality products for use in the fast development of the aircraft, aircraft engines, parts and accessories fields.

- A minimum of time is required to establish new specifications or to revise specifications already used by an industry dependent on constant improvements and innovations.

- AMSs result from decisions made by a cross-section of materials experts.

- AMS committee meetings provide an excellent forum where supplier-user problems may be discussed.

- The single number system used by AMS clearly identifies material requirements, minimizing the danger of mix-ups or errors in procurement, marking, stocking, and inspection.

AMS has different meanings for various branches of the aircraft industry. Typical of the expressions about AMS from engineers experienced in



SAE's 10 millionth Aeronautical Materials Specification is sold by Eve Gorvetzian, SAE staff coordinator of AMS publications, to David E. Waite (right), Associated Spring Corp. SAE President W. Paul Eddy (left) was present for the occasion.

TC Chairmen Guide Committee Work . . .



R. L. DOUGLAS, chairman of the Transportation and Maintenance Technical Committee, reports his Brake System Test Subcommittee is trying to develop an accurate and practicable test instrument to measure air build-up time in brake systems.

An operating group will be appointed shortly to make recommendations as to where brake system test instruments could best be attached to vehicle equipment when it is used for test purposes. It will determine the type of fitting that could best be incorporated as standard equipment in future design.

Douglas, director of Fleet Maintenance, Eastern Motor Express, Inc., says the Radio Communications Suitable for Automotive Fleet Application Subcommittee is very active establishing design criteria and standards for 2-way radio installation and operation.



P. J. SPERRY, chairman of the Construction and Industrial Machinery Technical Committee, reports the Tractor Test Code activities of both the CIMTC and the Tractor Technical Committee are being worked on in the Joint CIMTC-TTC Coordinating Test Code Subcommittee. Established to reduce the two procedures to common method and terminology, the Joint Subcommittee's goal is to provide industry with a single method for evaluating the performance of tractive vehicles.

CIMTC's 16 subcommittees deal with construction machinery problems such as rating performance, load capacities of machinery and their components, standardization of dimensions for interchangeability, nomenclature and terminology, and improved maintenance.

Sperry, division chief engineer, Product Engineering, Construction Equipment Division, International Harvester Co., recently commented on the significant amount of cooperation that can exist between competitors for their mutual benefit in technical committee work.



C. M. WRIGHT, chairman of the Automotive Drafting Standards Committee, believes in the need for closer industry understanding of basic and specialized drafting principles. He states that although the Joint Aero-Auto Drawing Standards activities have made rapid progress toward the consolidation of the drawing procedures and principles of the two industries, many drawing sections of the SAE Automotive Drafting Manual are still to be revised.

The SAE Automotive Drafting Committee recognizes this problem, and many of its subcommittees have been activated, particularly in Automotive Body Drafting.

Wright, standards engineer, Chrysler Corp., recently observed that in technical committee work, standardization takes place not by domination, but rather, by resolving problems point by point as progress is made toward better drafting standards.

their fields are the following comments received recently:

A. W. F. Green, technical assistant to executive engineer, Allison Division, GMC, believes that the AMS story cannot be told properly without reference to the many employers and industry management groups who have made it possible for their representatives to attend committee meetings.

R. R. Gutteridge, Aeronautical Division, Minneapolis-Honeywell Regulator Co., feels that in addition to the above benefits, "Representation in the AMS Division of SAE has put Honeywell in touch with the top technical talent of materials people in the aeronautical industry. Association with them has provided personal contacts which have been helpful in solving materials problems."

Charles M. Miller, materials engineer, Northrop Aircraft, Inc., tells of a group of fueling hose AMSs now being prepared for issuance. Requested by the Rubber Manufacturers Association, they reflect the recognition AMS has achieved from material suppliers. These specs when issued will be used for tank truck hoses at airport refueling facilities.

F. M. Morris, manager of Materials and Processes, American Airlines, Inc., stated that in an effort to procure methyl alcohol, a review of military specifications indicated that none existed which could meet his needs. Consequently, methyl alcohol-methyl alcohol/water mixtures were procured according to AMSs.

William C. Schulte, Propeller Division, Curtiss-Wright Corp., states that the aeronautical industry, more than any other, depends upon improvements and innovations in materials necessary for technological advancement. SAE's AMS Division is a means by which the aero industry may exercise its control over material specifications.

External Lamp Wiring Guideposts Established

GUIDEPOSTS for sound external lamp wiring practices among vehicle and body manufacturers are presented in SAE's new Recommended Practice, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring. Developed principally for use on new commercial vehicles 80 in. or more in width, they are also applicable to rewiring and service.

- Wire size related to ampere and length of circuit, insulation, and vehicle characteristics are considered.

- Values for wire design calculations are suggested for source voltage, volt-

age drop in connections, voltage drop in wiring, and design voltage of lamps.

- A voltage drop per foot versus lamp current graph for six wire sizes is included.

- Wire installation and protection, wire harnessing, and circuit grounding are recommended.

- Insulated cable, cable terminals, lamp requirements, circuit identification, and circuit protection are based on previously published SAE standards.

Trucks, truck-tractors, trailers, and motor coaches shall conform to specifications presented in the general section of the report. Additional requirements are presented for truck-tractors, trailers, and motor coaches.

A full account of the Truck, Truck-Tractor, Trailer, and Motor Coach Wiring Recommended Practice will appear in the 1957 SAE Handbook.

Shot and Grit Quality Tests Available June 15

METHODS for determining the quality of shot and grit are presented in SAE's new General Information Report, Metallic Shot and Grit Quality Testing. They will enable users to compare shot of different lots, and predict fatigue life expectancy for a given application.

A demand for a device to measure the quality of incoming shot was created when metallic shot for use in cleaning and peening operations was first introduced. Ideally, the testing machine would: (1) Compare various shipments of the same type of shot, (2) Compare the various types of shot, and (3) Accurately predict their life in actual production-type machines. Realistically, the Shot Peening and Blast Cleaning group, after four years of work on this problem, found it necessary to limit their aim to:

- Checking incoming shot for conformity with previous shipments of the same shot type from the same manufacturer.

- Obtaining data on comparative life of various types of shot under laboratory conditions.

It was found that testing machines could not be used to establish shot consumption or cost in production machines because of an inability to duplicate production conditions.

4 Different Shot Testing Machines

Four different shot testing machines have been developed and are available commercially. The machines vary con-

Technishorts . . .

Titanium and Titanium Alloys will make its first appearance in the 1957 SAE Handbook. The new General Information Report describes titanium sources, physical properties, commercially-pure titanium, all-alpha and alpha-beta weldable alloys, and alpha-beta nonweldable alloys. Four tables appear which deal with (1) Nominal Chemical Composition, (2) Physical Properties of Annealed Titanium, (3) Available Forms, and (4) Highest Temperature Recommended for 1000 Hr Service.

Work has begun on an American proposal for an American-British-Canadian standard on Quick-Attach-Detach flanges and drives. The Accessory Drive Panel of SAE's Joint Engine and Accessory Installations Committee is working on the project under Chairman E. G. Emery of Pratt & Whitney Aircraft. The development of the American proposal by the Drive Panel was requested by the Engine Technical Committee of the Aircraft Industries Association.

Automotive Nodular Cast Irons, a new SAE Recommended Practice, describes nodular (ductile or spheroidal graphite) iron castings for motor vehicles, agricultural equipment, and general machinery purposes. The processes by which the irons may be made, workmanship, machinability, physical properties, and grading are included. Emanating from the Automotive Iron Castings Division of SAE's Iron and Steel Technical Committee, the report will appear in the 1957 SAE Handbook.

Automatic Transmission Hydraulic Control System Terminology, a new SAE Recommended Practice, supplements existing Handbook information on Hydrodynamic-Drive Terminology. It is intended to clarify the specific area of control systems.

A new section for Hydraulic Tube Fittings will appear in the 1957 SAE Handbook. Developed to overcome problems of double flared tubing on automotive refrigeration equipment, the fittings are interchangeable with the present Automotive 45-Deg Flared Fittings and 45-Deg Marine and Refrigeration Fittings Standards.

Three new SAE Standards, developed within SAE's Parts and Fittings Committee, were approved for publication by the Technical Board. They are: **Spring Type Straight Pins, Straight Solid Pins,** and **Ground Dowel Pins.**

Drive standards for motors 1/20 hp and below have been developed by the Motors Subcommittee of SAE's Aircraft Electrical Equipment Committee. Included are three types of drive flanges: round flange with involute spline pinion, round synchro-type flange with involute spline pinion, and square flange with involute spline pinion. There are seven diameter sizes from $\frac{5}{8}$" to $1\frac{3}{4}$" in diameter. These standards were originated for ABC standardization. The form in which they will appear has not yet been determined.

Norman F. Rooke Honored at Dinner



NORMAN F. ROOKE accepts **SAE President W. Paul Eddy's** congratulations for technical accomplishments on Aircraft Engine Standards Committee E-21. Piloted O-ring fluid connection, safety wiring, tube joint brazing, and high temperature fluid connections projects accounted for his more recent work on the Committee's 54 projects.

Chairman H. B. Slusher and **Vice-Chairman A. E. Gibson** (l. to r.) presented the plaque at a dinner of E-21 members when Rooke left the Committee to take a new assignment at Pratt & Whitney Aircraft Division. Rooke's long and active career in the aircraft and engine industry was traced by G. N. Cole, member of the SAE Aircraft Engine Division, starting with pursuit plane design during World War I.

Committee members attending the dinner in Hartford on February 13 were: H. D. Culham, Orenda Engines Ltd.; A. E. Gibson, Lycoming Division, AVCO Mfg. Co.; R. G. Larkin, Allison Division, GMC; R. F. Schwarzwalder, Wright Aeronautical Division; D. J. Seidel, Westinghouse Electric Corp.; H. B. Slusher, General Electric Co. Other members are: J. E. Champion, Continental Motors Corp., and W. P. English, Fairchild Engine Division.

siderably in detail, but are alike in the following ways.

A sample of shot or grit accelerated to a velocity approximating that found in a production machine strikes a hardened target. The number of cycles (impacts) is counted, and the percentage of shot failure determined by means of a screen analysis. The data obtained may be used to check the uniformity of shot from shipment to shipment or to determine the relative fatigue life of various types of shot.

The report warns that results obtained will be no better than the sample tested. Therefore, it is extremely important to select a representative sample for testing. It also suggests that the test machine be recalibrated periodically or whenever off-standard conditions are observed.

Partial breakdown methods for checking uniformity of shot from the same source and the complete breakdown method for establishing the fatigue life of various types of shot, are outlined in the new report.

Partial Breakdown

The partial breakdown procedure is reasonably accurate for evaluating the same kind and size of materials from different sources or different shipments from the same source. It entails testing a representative sample of shot and, at given intervals, stopping the test to screen the shot. After the shot on the various screens is weighed individually, the results for each size may be recorded on a graph as a percentage of the original sample weight. All material passing through a given control screen (commonly 0.013") is arbitrarily discarded. The balance is returned to the machine, and the test continued for another interval, then screened, weighed and recorded. This continues until 55% of the original sample passes through the control screen. The number of time periods required to reach this point represents the average life of the sample for any screen other than the original.

Complete Breakdown to Stabilize Loss

The complete breakdown method to establish fatigue life requires two things: (1) That a test of shot or grit be run for a greater length of time, and (2) That the pulverized shot be removed periodically, weighed, discarded and replaced with an equal weight of new shot and the test continued. The test is complete when the loss rate is constant. The percentage loss per cycle and the approximate loss of shot per hour in production-type machines due to fatigue failure may then be readily determined.

New High Temp Brake Fluid Studied

A JUMP of 75 F over the present 300 F boiling point of SAE Heavy Duty Brake Fluid (70R1) was recommended by an SAE 70R3 Subgroup at a January 16 meeting. Fluids formulated to the proposed temperature would satisfy extreme braking conditions in heavy vehicles.

Field braking tests of last summer demonstrated the need for a new spec and the obsolescence of the Moderate Duty Spec (70R2) for newer passenger cars. Deletion of the Moderate Duty Standard was recommended by the Hydraulic Brake Fluids Subcommittee and approved by the Society this winter.

Reasons for the temperature chosen were:

- It provides a margin of safety over the highest temperature (350 F) recorded in mountain truck tests last summer.
- Fluids are immediately available.
- Since fluids boiling over 400 F are in the experimental stage, higher boiling point fluids were considered, but not recommended at this time.
- Both natural and synthetic rubber cups in the brake cylinders deteriorate rapidly at temperatures of 400 F and above.
- Field tests do not indicate the need

Continued on page 106

Sound Operating Policies Guide

C E P

THE Cooperative Engineering Program, SAE's service to industry, is endowed with a practical, sound set of operating philosophies.

That's what 1956 SAE Technical Board Chairman R. F. Kohr told a luncheon meeting of group leaders who achieve industry's financial support for CEP under Finance Committee Chairman A. T. Colwell. These soundly-conceived principles help explain why the cooperative technical product furnished by the Society through CEP yields benefits to industry.

Kohr listed these principles as follows:

• **GEARED TO INDUSTRY NEEDS**—All projects undertaken by SAE technical committees stem from requests from industry or government.

• **COOPERATIVE PROBLEMS ONLY**—The Society helps industry solve problems which lend themselves to cooperative activities such as (1) Standardization of common parts, (2) Simplification of size and variety of parts, (3) Performance of materials and equipment, and (4) Interchangeability of components parts.

SAE steers clear of problems better handled competitively by industry. Projects which might infringe upon the design prerogatives of individual companies are avoided.

• **TOP TECHNICAL MANAGEMENT**—The CEP program is under the direction of the Technical Board, a group of top engineers from the automotive and aircraft industries. Their broad, practical experience enables them to evaluate the projects undertaken and reports developed within the Society's technical committees.

All technical committee reports are approved by the Technical Board before being issued by SAE. Result: each report is produced by top technical men on the subject; it's reviewed from the standpoint of usefulness and practicability by broad-gauge, top-level industry engineers.

• **TOP TECHNICAL TALENT**—Technical committee members are selected for their technical competence and ability to contribute to the committee's work. Sound decisions are made by committeemen who use their own engineering experience as a basis for developing reports.

• **TECHNICAL TALENT EFFICIENTLY USED**—Technical Committees meet only when necessary. It's recognized that the time of engineers is valuable. So committee members are assigned the technical jobs to which they can most effectively contribute. Paperwork, meetings arrangements, and other details are handled by the staff.

• **JOB FINISHED**—The dynamic activity of forming and disbanding committees goes on constantly. Approximately 3,000 men serve on 260 committees, subcommittees, and groups under the SAE Technical Board.

Tooling Panel Visits GE's Evendale Plant



Members of the Tooling Panel of SAE's General Standards for Aircraft Engines Committee were guests of the Ground Support Equipment Sub-Section at General Electric's Evendale Plant, Cincinnati, Ohio, on January 22-23. The Panel is standardizing and unifying the various types of tools and ground support equipment used in aircraft engine maintenance and installation work. Pictured above are (l. to r.) H. E. Spencer, Wright Air Development Center; Earl Reagan, Allison Division, GMC; A. C. Cullen, GE; Harold Slusher, GE; H. Marcheschi, Air Logistics Corp.; G. P. Ludwig, GE; B. A. Beaton, Pratt & Whitney Aircraft; T. A. Lyle, Bureau of Aeronautics, U. S. Navy; L. B. Hansen, Panel Chairman, Pratt & Whitney Aircraft; and A. G. Twigg, GE.

CRC Releases Eleven New Reports

THE following Coordinating Research Council reports have been released for distribution and are available from SAE Special Publications Department.

(This is a complete list of CRC reports released since publication of the listing of CRC reports on page 94 of the September, 1956, SAE Journal.)

Aviation Fuels

Volatility

CRC-290—Vapor Pressure Relations of Gasolines (12/55). Priced at $4.00 to members; $8.00 to nonmembers.

CRC-294—Temperature Coefficient of Viscosity of Aviation Fuels (12/55). Priced at $1.00 to members; $2.00 to nonmembers.

CRC-295—Thermal Properties of Aviation Fuels in Relation to Fuel Evaporation Losses at Altitude (12/55). Priced at $1.00 to members; $2.00 to nonmembers.

CRC-299—Altitude Performance of Gas Turbine Fuels of Varying Volatility (April 1951). Priced at $2.00 to members; $4.00 to nonmembers.

Diesel Fuels

CRC-297—Progress Report—Combustion Characteristics—Ignition Delay Bomb, (Jan. 1953—June 1954). Priced at $1.00 to members; $2.00 to nonmembers.

CRC-298—Investigation of the Effects of Fuel Sulfur Content on the GMC-278A Submarine Diesel Engine Under Snorkel Conditions (10/55). Priced at $2.00 to members; $4.00 to nonmembers.

Motor Fuels

Combustion

CRC-304—Combustion Chamber Deposits, Instrumention (5/56). Priced at $1.00 to members; $2.00 to nonmembers.

Detonation—Full Scale

CRC-300—Octane Number Requirement Survey (1955). Priced at $2.00 to members; $4.00 to nonmembers.

CRC-305—A New Procedure for Plotting Octane Number Requirement Distribution Data (5/56). Priced at $1.00 to members; $2.00 to nonmembers.

Lubricants

Engine Oils—Motor

CRC-303—Field Equipment Survey of Valve Train Wear (10/56). Priced at $3.00 to members; $6.00 to nonmembers.

Gear Oils

CRC-302—Development of a Technique for Rebuilding CRC L-19 Gear Lubricant Test Axles (11/56). Priced at $1.00 to members; $2.00 to nonmembers.

Aero Drafting Manual New and Revised Parts

FIVE new and two revised parts of the SAE Aeronautical Drafting Manual are now available in kit form.

New

Applied Surface Finishes—deals with surface finishes to protect against corrosion, deaden reflection, build up surfaces, decorate, improve insulating or wearing qualities, improve moisture or fungus resistance, add luminescences, and reduce friction. It contains a general definition, types of applied surface finishes, design and drafting considerations in the selection of finishes, drawing practices for use in connection with these finishes, and illustrations to show application of practices.

Unified and American Screw Threads—developed to revise the straight screw thread portion of Section F of the SAE Aeronautical Manual. The new specification includes unified threads, expands the definition and designation of screw threads to include standard threads with long lengths of engagement, modified threads, special form threads, plated threads, and multiple threads.

Flat Pattern Development—describes methods used in flat pattern development. It includes a bend allowance formula for aluminum or steel sheet, a formula for the development of a 90° bend, a set back formula for angles of bend other than 90°, and a "J" value chart.

Drawing Revisions—presents various methods to revision and amend drawings. The report contains information on the use of revision blocks, drawing change notice, attachments as amendments to drawings, letters and/or numbers to identify revisions.

Hairsprings—Created originally for clocks and watches, hairsprings are now used in gauges, and in aircraft and marine instruments. The new specification describes materials necessary for hairspring manufacture, inside diameters, outside diameters, number of coils, torque measurement, and collets. Two figures appear to illustrate hairsprings with and without collet, and to illustrate other information needed for their manufacture.

Revised

The following revisions occurred in two standards.

Tolerance Expression in Angular Dimensioning—shows high and low angular tolerance limits as "recommended", suffixed angular tolerance as "optional". It explains the sequence of angular limits and the application of both methods of angular tolerancing. The illustration has been revised and new text added.

Definition of Term "Basic"—as it ap-

pears in Section E of the Manual. The word 'basic' is defined as it applies to dimension, size, hole, and shaft systems.

The above are available in kit form for $2.50. Write to SAE, 485 Lexington Ave., New York 17, N. Y.

Tire, Rim Sizes for Farm Tractors—New RP

PREFERRED Drive Wheel Tire and Rim Sizes for General Purpose Farm Tractor, a new SAE Recommended Practice, establishes a series of tire and rim sizes for several groups of farm tractors. Each group has one or more tire sections with a generally common rolling radius and outside diameter. The Tractor Technical Committee, responsible for developing the report, feels the following will be accomplished:

1. The number of sizes will be reduced.
2. Mounting points for all rims specified for each group are identical, permitting interchangeability on a common wheel.
3. The tractor, implements, and ground relationship will not be significantly disturbed when oversize tires are used.
4. Implements may be mounted closer to the rear axle, reducing auxiliary front end weight and bringing greater stability and safety.

Details may be found in the 1957 SAE Handbook.

Quality Control of Sintered Carbide Tools

QUALITY control tests of sintered carbide tool materials are presented in a new SAE Recommended Practice. The tests outlined are for hardness, specific gravity, and porosity.

Hardness Test—The Rockwell Hardness Tester method is recommended. Due to the importance of the accurate calibration of test equipment, a description of this operation is included.

Specific Gravity—The immersion, or weight in water versus weight in air method of determining specific gravity, is outlined. This measures the density of the tool material, and indicates the composition and extent of compression in the sintered process.

Porosity Test—For purposes of sample comparison, three groups of pictures are shown of various porosity sizes and clustering of uncombined carbon as it is found in polished, unetched sintered carbide surfaces.

The Recommended Practice will appear in the 1957 SAE Handbook.

Air Data Computer Systems Examined

RECOMMENDED minimum performance requirements for air data computers are being studied by SAE's Aircraft Instruments Committee, Accessory and Equipment Division.

Built primarily for high-speed aircraft, air data computers simplify and coordinate critical information about approaching air or ground objects. They may consist of one device or a number of devices to convert environmental factors surrounding an aircraft into information required by the pilot for proper navigation.

Basic requirements for the following components of air data systems will be considered: the air data computer, air data converter, static pressure and angle of attack compensator, true airspeed indicator, and combined airspeed and Mach indicator.

Input Variables

Input variables, designed to process indicated static pressure, total pressure, free air temperature, and angle of attack, will be studied.

Ultimate Outputs

Ultimate outputs will also be examined. They will include electrical signals for air density, air density times speed of sound, true airspeed, impact pressure, true angle of attack, pressure altitude, altitude error, altitude error rate, Mach number, Mach error, Mach error rate, and total air temperature.

Fred S. Bonney, United Air Lines, is chairman of the Aircraft Instruments Committee which consists of 27 representatives from the aviation industry.

Hydraulic Directional Control Valve Test Code

A TEST code for hydraulic directional control valves used primarily on industrial and construction equipment has been developed by SAE's Construction and Industrial Machinery Technical Committee. The new test code does three things:

1. It establishes standard conditions for directional control valve tests.
2. Outlines a procedure for conducting four rating tests.
3. Establishes a standard method of presenting directional control valve ratings or test data.

Conditions of Test

Seven controls are set for running the tests. They are: cleanliness of hydraulic fluid, fluid temperature (120 and 180 F), fluid viscosity, aeration control, pulsation and back pressure elimination, checking valve position and movement during tests, and limits of accuracy for test conditions and measuring equipment.

PRESSURE DROP measurements across valve passages for all operating functions are required. For double and single acting valves, the flow rate is increased from 0 to 150% of maximum rated volume in 20% increments and pressure drop reported at each flow. (See Fig. 1 for schematic of test setup.) When a single acting valve is in the "lower" position, the pressure drop from the cylinder port to the tank port is measured for flow rates up to 200% and back down to 0% of rated flow.

LEAKAGE is picked up at the valve outlet when maximum operating pressure is applied to blocked cylinder ports. It is measured in cubic inches per minute with the valve in the "hold" position.

OPERATING EFFORT AND STABILITY of the valve control mechanism is nailed down by tests under circuit pressure, cylinder pressure, and no load conditions. The first test is run at 100% rated volume and 75% maximum operating pressure while the last is at 100% rated volume and maximum rated tank port pressure. The maximum force or torque exerted to shift the valve, with and without centering springs and detents, is reported.

INTEGRAL RELIEF VALVES are checked for operating pressure at flow rates from 5 to 150% of rated flow. Ten percent flow intervals are taken up and down this range, with the full flow relief valve pressure taken at the 100% flow rate step on decreasing flow run.

Test Data

Standard method of reporting results requires plotting of pressure drop and relief valve tests. Leakage, operating effort, and information on the valve is tabulated. Separate reports are issued for each fluid test temperature and section of double acting valves.

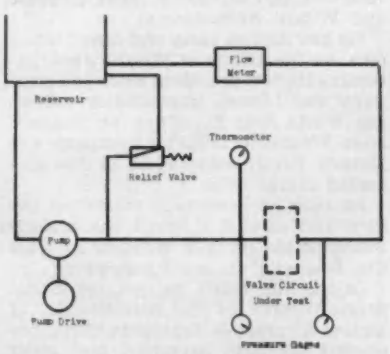


Fig. 1—Test Circuit

NEWS OF SAE

Rentschler . . .

. . . to receive Guggenheim Award posthumously at the 1956 SAE Aeronautic Meeting.

THE Daniel S. Guggenheim Award is to be presented posthumously to Frederick B. Rentschler on April 3 at the SAE National Aeronautic Meeting in New York. Rentschler, who was chairman and chief executive officer of United Aircraft Corp. at the time of his death on April 25, 1956, was chosen to receive the award, in the words of the citation:

> "For a wide range of major achievements throughout a lifetime devoted to aviation, with specific reference to his many notable contributions to the vital aircraft-engine field."

The award will be accepted by Mrs. Norman P. Patch and Mrs. Ann B. Rentschler, daughters of the recipient.

Rentschler was a pioneer and a leader in the development of aircraft powerplants. He early recognized that the engine is the heart of the airplane and foresaw that the aircooled piston engine would displace the liquid-cooled type. His persistence was substantiated by the fact that, during World War II, 85% of the airplanes flown by American and Allied air forces were powered with aircooled piston engines designed by Pratt & Whitney Aircraft and Wright Aeronautical.

He had had an early and direct influence on the affairs of Wright Aero, becoming its first president when the company was formed immediately following World War I. When he resigned from Wright in 1924, the company was already firmly established in the aircooled engine field.

In 1925 he personally conceived the idea and carried through the organization of the Pratt & Whitney Aircraft Co., becoming its chief executive.

In the late 1920's he was one of the prime movers in the organization of United Aircraft & Transport Corp., becoming its first president and chief executive officer.

His contributions were not confined to the piston-engine field, but were continued as the gas turbine engine came into use. Under Rentschler, Pratt & Whitney made remarkable progress in the jet-engine field, developing such engines as the J-57 and the larger J-75.

Zimmerman . . .

. . . awarded 1956 Wright Brothers Medal for paper on VTOL aircraft.

CHARLES H. Zimmerman, head of the Dynamics Stability Branch and assistant chief, Stability Research Division, Langley Aeronautical Laboratory, NACA, will receive the 1956 Wright Brothers Award on April 5, at the SAE National Aeronautic Meeting, New York City. The award will be made for his paper, "Some General Considerations concerning VTOL Aircraft," which was presented at the 1956 SAE National Aeronautic Meeting in New York, and will be published in full in the 1957 SAE Transactions. W. B. Bergen, chairman of the Board of Award, will make the presentation.

Zimmerman received his B. S. in Electrical Engineering from Kansas University in 1929, and his M. S. in Aeronautical Engineering from the University of Virginia in 1955. He joined the NACA Langley Laboratory in 1929. In 1937, he left the NACA to supervise development of VTOL aircraft design at Chance Vought Aircraft Division of United Aircraft Corp. He returned to Langley as aeronautical research scientist in 1948.



Wright Brothers Award winner Charles H. Zimmerman

The paper for which Zimmerman is getting the award discusses fundamental considerations that affect the practical utility of VTOL aircraft. Various types of these aircraft are considered in relation to their suitability to various uses. It states that, for applications requiring much hovering flight, helicopters are unchallenged.

For applications in which hovering is not an intrinsic part of the mission but hovering capability is needed to make possible successful operational use of unimproved fields or small airports, the author considers the VTOL airplane most attractive. He also discusses the most urgent research and development needs in connection with VTOL aircraft.

The Wright Brothers Award is made annually to the author of the best paper on aerodynamics or structural theory or research, or airplane design or construction presented at a meeting of the SAE during the calendar year.

You'll . . .

be interested to know . . .

MERRILL R. BENNETT, assistant manager of engineering, International Harvester Co., and **DALE D. STREID**, manager, engineering, General Electric Co., have been appointed to serve as SAE-Nominated Directors on the CRC Board for a term of two years beginning Jan. 1, 1957.

Planning for Progress Committee Is Looking Ahead to automotive engineering as a broad, ever-changing area covering the design, development, manufacture, and operation of transportation machines. They see potentials of even greater change in the character of transportation machines brought about at an even more accelerated rate than in the past. (From a report to SAE Council.)

The 1957 Nuclear Congress' opening ceremonies were held on March 10. **Dr. E. W. Landen,** Caterpillar Tractor Co., was SAE's representative.

SAE will join in sponsoring the Nuclear Congress in 1958 and will be represented on the General Committee and the Science Conference Committee.

Three Days Needed for Expanded L.A. Forum



Growing, growing, growing . . . that's been the history of the SAE Aircraft Production Forum in Los Angeles each year. To accommodate the anticipated attendance at the Forum this coming October, the Executive Committee for the Aircraft Production Forum agreed to run its program over a three-day period.

The Forum will start on Monday, September 30, and will run through Wednesday, October 2.

The Forum, which has been an outstanding feature of the SAE Aeronautic Meeting in Los Angeles each year, will be run for the seventh year in succession this Fall. Shown above are some of the planners of this Forum who are members of its Executive Committee.

They are left to right: Seated—J. A. Logan, Solar Aircraft Co.; E. T. Price, Solar Aircraft Co., Sponsor; B. K. Bucey, Boeing Airplane Co., General Chairman; E. W. Rentz, SAE Staff. Standing—R. L. Clark, Ryan Aeronautical Co.; A. W. Morgan, General Dynamics Corp.; H. V. Schwalenberg (representing W. F. Snelling), North American Aviation, Inc.; N. H. Shappell, Douglas Aircraft Co., Inc.; C. S. Wagner, Lockheed Aircraft Corp.; J. A. Van Hamersveld, Northrop Aircraft, Inc.

Executive Committee members not shown: C. E. Barnes, Rohr Aircraft Corp.; C. S. Glasgow, Douglas Aircraft Co., Inc.; W. F. Snelling (represented by H. V. Schwalenberg), North American Aviation, Inc.

SAE National Meetings . . .

1957

June 2-7
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 12-16
West Coast Meeting
Olympic Hotel, Seattle, Wash.

September 9-12
Tractor Meeting and
Production Forum
Hotel Schroeder, Milwaukee, Wis.

September 30-October 5
Aeronautic Meeting,
Aircraft Production Forum,
and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Oho

1958

January 13-17
Annual Meeting and Engineering
Display, The Sheraton-Cadillac
and Statler Hotels, Detroit, Mich.

About SAE


Delaney


Harder


Schmitz


Blood


Healy


Forster


Prosser


Klikunas

GEORGE A. DELANEY, chief engineer for Pontiac Motor Division, General Motors Corp. since 1947, has retired after nearly 23 years of service with the company. Since September, 1956, Delaney has been on special assignment on the staff of **S. E. KNUDSEN,** Pontiac general manager.

SAE president in 1956, Delaney remains a member of SAE Council as a past-president through 1957–1958. He plans to continue his many other SAE activities, which currently include membership in the Planning for Progress Committee and the treasurership of SAE Detroit Section.

A native of Centerview, Mo., and a graduate of the University of Missouri, Delaney joined General Motors and Pontiac in 1934 as an electrical engineer and in 1939 was named assistant chief engineer. In 1942 he went to Fisher Body Division as supervisor of aircraft engineering and returned to Pontiac in 1945 as assistant chief engineer.

Largely responsible for the development of Pontiac's Strato-Streak V-8 engine, Delaney's engineering know-how has long been a principal factor in the company's success.

DEL S. HARDER has been appointed executive vice-president of Ford Motor Co. He formerly was executive vice-president—Basic Manufacturing Divisions.

In addition to his responsibilities over the Basic Manufacturing Divisions, Harder will now have responsibility over all Car, Truck, and Tractor Divisions as well. In connection with his new responsibilities for the Car and Truck Divisions, he will primarily concern himself with their manufacturing and assembly operations.

D. J. DAVIS, who has been vice-president—Manufacturing, on the company's central staff, continues in that capacity, reporting directly to Harder.

CARL E. SCHMITZ has been named executive vice-president of Crane Packing Co., Morton Grove, Ill. Prior to this appointment, he was vice-president in charge of sales for the company.

ROYCE C. BLOOD has been appointed branch manager at Fresno, Calif., for C & C Trailer & Body Co. He joins C & C after having served in an executive capacity with Southern California Freight Lines in Los Angeles for 15 years, California Truck Rental for two years, and Fortier Transportation Co. in Fresno for three years.

DUNCAN McRAE has been appointed director of styling in charge of the newly established corporate styling studies, Studebaker-Packard Corp., South Bend, Ind.

McRae has been in charge of Studebaker styling since joining the company in February, 1955.

Previously, he had been chief stylist, Kaiser-Willys. Prior to that, he headed the exterior styling studio and body development group, Ford Division, Ford Motor Co.

EARL W. BALL has been named manager of Esso Standard Oil Co.'s Railroad Sales Division. He has been assistant manager of the division since 1951.

Ball was supervisor of auxiliary equipment for the New York, New Haven and Hartford Railroad before joining Esso in 1942 as a railroad sales engineer.

ROBERT G. HILL has been appointed sales manager of the Original Equipment Division of the Leece-Neville Co. Formerly, he was a sales engineer for the company.

Hill first joined the company in 1941 as a tester. He subsequently served in its engineering department, and in 1947 was made a service engineer in the company's technical service department.

ROBERT W. WOLFE has been named general sales manager and a member of the board at New Process Gear Corp., Syracuse, N.Y. He had been chief engineer at the company.

Associated with New Process Gear since 1954, Wolfe will be responsible for the administrative coordination of the Sales Division and its activities.

FRANCIS P. HEALY has been elected a director of Van Norman Machine Co., Springfield, Mass. He is vice-president of Van Norman Automotive Equipment Co.

J. F. FORSTER has been appointed executive vice-president of Vickers, Inc. He joined the Vickers organization as treasurer in 1941 and was made vice-president and assistant general manager in 1949. Previously, he had been production planning manager for Sperry Gyroscope Co.

Forster will have direct charge of all Vickers operations.

DUANE R. PROSSER is now a mechanical engineer in the reactor mechanism section of the Reactor Design Division with Westinghouse Electric Co.'s Atomic Powerplant in Pittsburgh.

Previously, Prosser was mechanical engineer, Bureau of Aeronautics, U.S. Navy Department, Washington, D.C.

RICHARD V. KLIKUNAS has joined the Fort Wayne Division, Bowser, Inc., as chief engineer. Previously, he was chief engineer, Buckeye Iron and Brass Works, Dayton, Ohio.

Members



McRae



Ball



Hill



Wolfe



Miller



Sulzman



Hundley



Nelson

PAUL A. MILLER, formerly general manufacturing manager for Ford Motor Co.'s Parts and Equipment Division, has been named general manager of the Accessory Division at Ford.

Prior to joining Ford in 1954, Miller was vice-president of the Leece-Neville Co., Cleveland.

EDMUND C. SULZMAN, formerly vice-president in charge of sales for Jack & Heintz, Inc., has been named general sales manager, Aviation and Ordnance Division of the Weatherhead Co., Cleveland.

Sulzman previously served with Wright Aeronautical Corp. from 1934 to 1951.

ROY A. HUNDLEY has organized Hundley Engineering of Sunnyvale, Calif. The new firm will offer consultation and design services and establish technical sales and service representation.

Hundley had been director of engineering for Wetmore Hodges and Associates, Inc., Redwood, Calif.

BERT S. NELSON has been appointed director of engineering for the Products Division of Hills-McCanna Co. He had been chief engineer at Foote Bros. Gear and Machine Corp.

ROBERT E. WERDER is now industrial salesman in Atlanta, Ga. for the Texas Co. Previously, he was general salesman in Spartanburg, S. C. for the company.

Werder will handle sales and engineering application of Texaco Petroleum products for industries.

WILLIAM A. THOMAS, formerly a sales engineer in Milwaukee for the Goodyear Tire and Rubber Co., has been transferred to Detroit.

Thomas will represent Goodyear at the Buick, Oldsmobile, and Cadillac factories on sales and engineering of automotive rubber items.

CHARLES KNIGHT has been named general manager of the Facsimile Equipment Division, Air Associates, Inc. He has been with Air Associates for nine years during which time he has served as chief design engineer, and most recently, as administrative engineer.

Knight who has 17 years of experience in electronics and allied fields, will now be responsible for all aspects of the company's facsimile program which includes the planning of engineering programs, sales, sales promotion, production requirements and service.

WALTER F. ROCKWELL, a member of SAE Finance Committee, has become charman of the Finance Committee of Rockwell Mfg. Co. He was formerly chairman of Acro Mfg. Co. whose assets were acquired by Robertshaw-Fulton Controls Co. of which Rockwell has been a director.

Rockwell had been chairman of the board of Acro. He is also chairman of the finance Committee of Rockwell Mfg. Co.

MERRILL J. ANDERSON, previously a project engineer, research laboratories, Ethyl Corp., is now an automotive engineer in the eastern region of Ethyl's sales department.

Anderson has been associated with the Detroit research and development laboratories of Ethyl Corp. for the past 18 years, and has been active in many research projects in the diesel and gasoline fields.

In recent years, he has been with the agricultural engineering section of the laboratories' Technical Service Division.

DONALD JOHN ZWENG is now a design engineer, reactor components, Atomics International Division, North American Aviation, Inc. He was systems group supervisor, Missile Division, Chrysler Corp.

HENRY B. HUTTEN, JR. is now a programming engineer in the jet engine department, General Electric Co., Evendale, Ohio. Previously, he was a programming engineer, Engineering Division, Chrysler Corp.

LAWRENCE J. EASTERDAY, JR. has been named chief engineer to direct research and development of new products in the automotive department of the John Bean Division, Food Machinery and Chemical Corp. Prior to joining John Bean, he was chief test engineer, Allen Electrical and Equipment Co. of Kalamazoo.

GRANT B. STONE has been made senior sales representative, turbine and controls, Sales Division, Solar Aircraft Co. Since 1950 he has been manager of Solar's Los Angeles district office.

CLIFFORD YOUNIE is now customer service manager for the division. He has represented Solar in the southwest district in Fort Worth, Texas, since 1955.

GEORGE G. DESCAMPS is now a development engineer, Edsel Division, Ford Motor Co. Formerly, he was chief tester, Studebaker-Packard Corp.

ROBERT B. KEEFLER has been made manager, technical service, British Petroleum of Canada Ltd. Previously, he was manager, sales and technical service, Bardahl Lubricants Ltd.

ROBERT M. WARD has been made special representative for the west coast for Champion Spark Plug Co., Toledo, Ohio. He had been assistant sales manager for Champion.

GM Changes



Boegehold



Campbell



Underwood



Flynn

JOHN M. CAMPBELL, who has been technical director, Research Staff, General Motors Corp., since 1954, has been named scientific director for the company. In this newly created position, he will serve as principal assistant to **DR. LAWRENCE R. HAFSTAD,** vice-president in charge of research at GM.

ARTHUR F. UNDERWOOD, who has headed the mechanical development department, was elevated to manager of Research Staff activities.

GREGORY FLYNN, JR. succeeds Underwood as head of the mechanical development department. He had been assistant head of the department.

The promotions result from the retirement of **ALFRED L. BOEGEHOLD,** manager of research activities and principal assistant to Dr. Hafstad. Boegehold will continue as a consultant to Research Staff following his retirement. He is a veteran of 36 years with GM.

HERBERT ERICKSON is now a planning engineer, Atomic Power Division, Westinghouse Electric Corp. Previously, he was planning coordinator, Research Division, Curtiss-Wright Corp.

JAMES F. VOJTEK has been appointed chief test engineer, Sun Electric Corp. For the past seven years, he has been with the company as a project engineer.

LEON HENSCHEL is now a salesman with the Potter Oldsmobile Co., North Miami, Fla. Previously, he was president of Montclair Machine and Mfg. Co. in Caldwell, N. J.

GEORGE C. SCHRADE has been made city manager truck operation, Hertz Corp., Baltimore, Md. He was city manager, Akron, Ohio, for the company.

Schrade will be responsible for the management of truck operation in Baltimore which includes maintenance, purchasing of trucks, selling of truck leases, and setting up specifications and quotations for new units leased.

T. J. AULT, president and general manager of Long Mfg. Division, Borg-Warner Corp., was guest speaker at the Command Management School, Fort Belvoir, Va., where he discussed "Diversification of Management."

CLARENCE E. HOLTSINGER has been appointed chief engineer for the Connecticut Aeronautic Nuclear Engine Laboratory (CANEL), Pratt & Whitney Aircraft Division, United Aircraft Corp. Since 1956, he has been assistant chief of the program for coordinating the non-technical aspects of the company's nuclear propulsion program for the Air Force and the Atomic Energy Commission.

Holtsinger joined Pratt & Whitney Aircraft in 1951 as assistant licensee liaison engineer, and two years later was named assistant to the general manager in charge of the nuclear engine program.

ALFONS G. TAYLOR has been made advertising manager, display, special editions, Norfolk Newspapers, Inc., Norfolk, Va. Previously, he was engineer and sales director, Relax-It Vibrator Co., North Hollywood, Calif.

LYLE DAVIS has been made sales manager, Wholesale Division, Cincinnati-Vulcan Co., Inc. Previously, he was sales manager, national accounts, Macmillan Petroleum Corp.

FORD L. PRESCOTT, formerly a mechanical engineer, Continental Aviation and Engineering Corp., Detroit, is now a professor and research engineer at the University of Florida. Prescott's teaching duties will include courses in thermodynamics and the internal combustion engines.

He has served as chairman of the SAE Dayton Section and also has presented several papers at Section meetings.

FRANK J. SVEKRIC, formerly a design group leader with Cadillac Motor Car Division, General Motors Corp., is now assistant to the vice-president of engineering at Raymond Corp., Greene, N. Y., manufacturers of electric and hydraulic lift trucks.

J. E. KLINE has been made manager, Petroleum Additives, for the newly organized Amoco Chemicals Corp. Previously, he was director, Stan-Add Sales Division, Standard Oil Co.

Amoco Chemicals was formed by the consolidation of Pan American Chemicals Corp. Indoil Chemical Co., and Hidalgo Chemical Co., all subsidiaries of Standard Oil Co. of Ind.

ELDON W. TIBBITS, formerly a test and development engineer, Chrysler Proving Grounds, Chrysler Corp., has joined the General Motors Corp.'s Proving Grounds, Chevrolet Division, as a test engineer.

Tibbits' duties will include development and production testing of passenger cars and trucks.

H. H. WILDER has been named manager, engineering sales, Vanadium Corp. of America, Chicago. Prior to this appointment, he was assistant manager of engineering sales in Detroit for the company.



Staub | Pigott | Fitzgerald | Buttner



Killebrew | Cary | Miller | Jordan

CHARLES R. STAUB, former chief engineer, Michigan Tool Co., has retired. For the past two years he has been serving as a staff consultant to the company.

Staub began a life-long career in metalworking as an apprentice tool, die, and gage maker in Tiffin, Ohio, just after the turn of the century.

He joined Michigan Tool in 1929 and was named chief engineer in the early thirties—a post he held for more than 20 years.

Staub, a recognized authority on gears and gear cutting, shaving, lapping, and finishing equipment, was a member of the government's Central Aircraft Counsel during World War II.

PAUL PIGOTT, president of Pacific Car and Foundry Co., was named to the Boeing Airplane Co. board of directors.

Pigott previously served as a member of the Boeing board from 1936 to 1942. He is presently a director of the Standard Oil Co. of California and of the Washington Mutual Savings Bank.

GLEN R. FITZGERALD has been appointed chief automotive engineer at AC Spark Plug Division of General Motors Corp. He has been director of the process development section of the GM manufacturing staff since 1953.

Fitzgerald is a member of the SAE Production Activity Committee and is also serving as Detroit Section Production vice-chairman.

H. J. BUTTNER, who was manager of engineering for the LeRoi Division of Westinghouse Air Brake Co., has been appointed chief engineer of McCulloch Motors Corp., Los Angeles.

In his new post, Buttner will supervise activities of the entire engineering Division, including experimental test, production engineering, chain saw and supercharger development, and target engine development departments.

CLARENCE E. KILLEBREW was elected president of the Construction Industry Manufacturers Association. He is vice-president, Clark Equipment Co., Construction Machinery Division, Benton Harbor, Mich.

BEECHER B. CARY has been elected vice-president of engineering and research for the Standard Products Co. He joined Standard Products in 1951 as director of engineering and research. Formerly, Cary was vice-president in charge of engineering and a director of Hayes Industries, of Jackson, Mich.

JAMES ALVIN MILLER is now a product engineer, Industrial Truck Division, Clark Equipment Co. Previously, he was a development engineer in the Transmission Division at Clark.

He will be responsible for all engineering of internal combustion engine powered industrial fork trucks from 1000 lb to 10,000 lb load capacity.

Miller is currently a member of SAE Transmission Committee. In addition, he has served as chairman of the Detroit Section's Junior Activity and as a member of the Joint SAE-ASTM Committee on Oil Seals.

WILLIAM C. JORDAN pioneer aircraft manufacturing executive, has been named a director of Solar Aircraft Co. A former president of Curtiss-Wright Corp., he was executive vice-president of Hughes Aircraft Co. until mid-1954. He now lives at Valley Center, Calif.

Jordan is active in a variety of business and industrial organizations. He is chairman of the board of B. M. Heede, Inc., New York; president of the Seymour Tool and Engineering Co., Seymour, Ind.; and a member of the board of directors of over a half dozen concerns.

DOUGLAS R. REMY is now a passenger car body design engineer, Chevrolet Division, General Motors Corp. Previously, he was a styling engineer with Chevrolet.

Remy is currently serving on the SAE Body Activity Committee.



PAUL E. ALLEN, (left), quality control manager of Beech Aircraft Corp., is presented with the Greer Maintenance Award for 1956 by **EDWARD M. GREER,** president of Greer Hydraulics, Inc., for the outstanding contribution to the aircraft maintenance field for 1956.



COLONEL ALBERT A. ARNHYM (right), director of information services of Air Research and Development Command (ARDC), is congratulated by Lt.-Gen. Thomas S. Power, ARDC Commander, who has just presented the Colonel the Legion of Merit in ceremonies at ARDC Headquarters in Baltimore, Md.

Colonel Arnhym was honored for exceptional meritorious service to the United States by developing a most efficient means of informing all military and civilian elements of this country of the USAF's research, development, and test program. This information is made available through the ARDC Staff film reports, a program initiated and directed by the Colonel.

HARRY J. GRAHAM has been named director of engineering, Engine Development Division, Clinton Machine Co., Clinton, Mich. He formerly was with the Lycoming Division, Avco Mfg. Corp.

GEORGE KRIEGER has been appointed special assistant to the director of public relations for Ethyl Corp. Previously he was manager, Agricultural Division, at Ethyl.

Krieger who has been associated with Ethyl since 1929, will be in charge of the company's public relations activities in the agricultural field.

WERNER G. BAULE has been made a research engineer at Borg-Warner Corp.'s research center in Des Plaines, Ill. Previously, he was a design engineer with the company's products development laboratory.

FRANK J. SARGENT has joined Ashland Oil and Refining Co., Ashland, Ky. as industrial sales manager. Previously, he was executive assistant for Allied Oil Co., Cleveland.

H. S. CONRAD has been made president of Stackpole Carbon Co., St. Mary's, Pa. He formerly was vice-president and general manager of the company.

THEODORE S. JOHNSON has been named operations manager for Socony Mobil Oil Co. de Venesuela, Caracas, Venesuela. Prior to this appointment, he had been manager, engineering and operations department, Mobile Oil Egypt, Inc., Cairo, Egypt.

ELMER D. SOWERS has been made shop manager, Consolidated Freightways, Inc. Formerly, he was assistant shop manager for the company.

Sowers currently is serving as SAE Oregon Section secretary.

CHARLES C. CONLEY has been named head—electrochemical process and materials development, Cleveland Graphite Bronze Co. Prior to this appointment, he was administrative manager, research and engineering, Houdaille Industries Inc.

RODGER J. EMMERT, assistant to the vice-president in charge of Process Development Staff, General Motors Corp., has retired after 38 years of service.

An electrical engineering graduate of Case School of Applied Science, Cleveland, Emmert began in industry with the former Remy Electric Division.

In 1927, he was sent to Dayton, Ohio, as factory manager of the Delco Division of GM's former Delco-Remy Corp., and two years later was made president and general manager of Delco Products Division.

Emmert was named to the presidency of General Motors Radio Corp. in 1930. Two years later, he was named factory manager of GMC Truck & Coach Division and remained there 16 years.

In 1948, he became executive in charge of facilities and processes activities of the Manufacturing Staff, including supervision of the newly organized process development section now located at General Motors Technical Center.

In August, 1956, he was named assistant to the vice-president in charge of Process Development Staff, the position he held until his retirement.

Emmert is a past SAE vice-president for Production.

MARVIN F. SCHOBERT has been named product manager, standard exchangers, Ross Heat Exchanger Division, American-Standard.

He has been with Ross since 1941, his most recent position being assistant manager of the Chicago district office.

RICHARD H. AXNESS is now a field representative for Caterpillar Tractor Co. Prior to this new appointment, he was a technical correspondent for Caterpillar.

JEREMIAH HALPIN is now with the Ford Motor Co. in industrial truck repairs at the company's Stamping plant. He had been a diesel instructor at Tractor Training Service Inc. in Chicago.

WILLIAM J. FINNELL has been made assistant manager of sales, American Bosch Division, American Bosch Arma Corp. Prior to this appointment, he was a field engineer with the company.

PERRY W. PRATT has been named assistant engineering manager of the Connecticut operations, Pratt & Whitney Aircraft Division, United Aircraft Corp. He has been the division's chief engineer since 1952.

Pratt joined Pratt & Whitney in 1937 as a test engineer and subsequently held the positions of assistant project engineer, project engineer, head of the technical and research section of the gas turbine department, and assistant chief engineer.

LEONARD VELANDER has joined John S. Barnes Corp. as a project engineer. Formerly, he was a research engineer at the Borg-Warner Corp.'s research center.

A. T. COLWELL, vice-president, Thompson Products, Inc., was guest speaker at the American Society of Mechanical Engineers' Second National Gas Turbine Power Conference in Detroit last month.

WILLIAM A. SWOPE is now an instructor at the University of Colorado. Formerly, he was a development engineer with Cessa Aircraft Co., Wichita, Kan.

GEORGE M. BUNN, formerly with the firm of George M. Bunn and Associates, is now a consultant with the B.T.C. Truck Rental Co. in Baltimore.

CHARLES G. FLETCHER is now a mechanical engineer with Jerguson Gage and Valve Co., Burlington, Mass. Previously, he was a project engineer with Smith, Hinchman and Grylls, Inc.

B. E. DERRY has been named general manager of the French & Hecht Division of Kelsey-Hayes Co. He had been sales manager of the division.

WILLIAM R. WEST is now a test engineer with the Atomic Power Division, Westinghouse Electric Corp. Previously, he was maintenance officer, Fighter Squadron 101, Department of the Navy.

JOHN CENKO is now with the product engineering department, Automatic Transmission Division, Ford Motor Co. Previously, he was chief product engineer, Marvel-Schebler Products Division, Borg-Warner Corp., Decatur, Ill.

ALEXANDER A. MITTENBERGS is now principal mechanical engineer, Battelle Memorial Institute, Columbus, Ohio. Previously, he was senior designer, New Holland Machine Division, Sperry Rand Corp.

Mittenbergs will do research work in the Applied Mechanics Division at the Institute.

LINUS J. RAUSCH is now plant manager, Chevrolet-Norwood Division, General Motors Corp. Previously, he was plant manager for GM's Chevrolet-Janesville Division.

JACK JOERNS has joined Kirk Engineering Co., Los Angeles, as a design engineer. Previously, he was senior design engineer, Convair Division, General Dynamics Corp.

J. M. VAN DAM has been made manager, material control, Aviation Gas Turbine Division, Westinghouse Electric Corp. Previously he was executive assistant to the works manager for the division.

JOHN E. KELLY has been made manager, St. Louis zone, Truck & Coach Division, General Motors Corp. Previously, he was with the company's Chicago retail store.

W. W. MERRYMAN has been transferred to Continental Oil Co.'s Technical Services Division in Ponca City, Okla. He previously was a technical services representative for the company in Minneapolis.

ARTHUR C. COCAGNE, has been made vice-president in charge of field engineering with Telecomputing Corp., Van Nuys, Calif. Prior to this appointment, he was director of field engineering with Telecomputing.

KEMPTON H. ROLL has been made executive secretary and treasurer, Metal Powder Association, New York, N. Y. He had been technical director of both the Lead Industries Association and the Metal Powder Association.

HARRY M. McCULLY has been made Eastern Division service manager, Clark Bros. Co., Inc. Previously, he was senior instructor, General Motors Institute, Flint, Mich.

Continued on page 105

Obituaries

PETER M. HELDT

Peter Martin Heldt, pioneer member of SAE and noted author and technical editor, died March 11, following a brief illness. He was vacationing in Miami. Services were held in Nyack, where Heldt lived for more than 40 years.

Heldt was the author publisher and author of numerous widely used automotive text books, many of which have been translated into several languages.

Born in Staberdorf auf Fehmarn, Schleswig-Holstein, Germany, Heldt finished his primary school education before coming to the United States at about 15 years of age.

Upon arrival here, he went to work on a farm in Iowa. Then one day he received "a promotion letter." It was from the Highland Park Normal College describing the great opportunities for young men in the field of electrical engineering. "At that time," Heldt used to reminisce, "the promotion young men heard about electrical engineering was much like that heard today about electronics."

He was impressed by the letter . . . and, in 1894, was graduated from Highland Park (now Des Moines University).

He started to write when he got an assignment from *Electrical World* and *Horseless Age* to cover the Paris World's Fair for those publications in 1900. He had been working with Munson Co., which planned to produce a gasoline-electric car. The car did get designed, but only three or four were ever built. When the company blew up, Heldt decided on a visit to the old country before starting some new activity. On his way, he stopped in New York to see the publisher of both *Electrical World* and *Horseless Age*—and got the Paris assignment.

When he came back again to deliver his material to *Horseless Age* (a forerunner of *Automotive Industries*), he found Ingersoll absent from his office.

But by the time Heldt got back to Iowa, Ingersoll had returned to New York, let out several members of his staff, and written Heldt asking him to come to work on *Horseless Age*.

That was the beginning of more than 40 years of fruitful achievement as an engineer editor. *Horseless Age* was bought by the Class Journal Co. and combined with *The Automobile* to become the present *Automotive Industries* . . . now a part of the Chilton Co. . . . And Heldt stayed with that same publication through its various changes of management until 1943, when he retired to devote his entire time to revising and publishing his text books. He was active in this work until his death.

In 1902, Heldt wrote an editorial in *Horseless Age* which first suggested a Society whose field of major activity would be "the purely technical side of the automobile." For this, SAE Council awarded this famous technical writer a life membership in SAE in 1953. SAE President Robert Cass said at that time: "It is fair to say that this editorial was the seed from which Ed Birdsall's efforts brought to fruition just such a Society, the Society of Automobile Engineers, in 1905.

"Heldt's thousands of technical articles have been post-graduate engineering courses to thousands of automotive engineers of all ages."

When Heldt retired from *Automotive Industries*, the SAE Council officially expressed to him its appreciation of the "important role you have played in furthering the ideals upon which you and other pioneers originally formed the SAE. Your work and your personal activities have symbolized to thousands of members a practical attainment of those high concepts."

And again, SAE honored Heldt in 1955 when he was selected as the representative of SAE's pioneer members at the Society's celebration of its Golden Anniversary.

Section Meetings

ALBERTA
April 26

BRITISH COLUMBIA
April 15 . . . S. G. Jones, supervisor industrial & commercial sales, Imperial Oil, Ltd., Vancouver, B. C.—"Abusing Your Engine." Hotel Georgia. Dinner 7:00 p.m. Meeting 6:15 p.m. Special Features: Representative speakers from other major local oil companies.

BUFFALO
May 8 . . . Rochester Meeting. "Outboard Motor Design." Dowd Post American Legion. Buffalo Road, Rochester, N. Y. Dinner 6:45 p.m. Meeting 8:00 p.m.

CANADIAN
April 26 . . . Windsor Meeting. **John Fisher,** managing director, Canadian Travel Association. Prince Edward Hotel.

CENTRAL ILLINOIS
April 29 . . . Annual Student Meeting. Two students from University of Illinois and two students from Bradley University will present papers. Cash prizes will be awarded. Pere Marquette Hotel. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO
May 14 . . . Dr. H. B. Osborne, Jr., technical director, Tocco Division, Ohio Crankshaft Co.—"A Good Look at Automation." Hotel Knickerbocker, Chicago. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour 6:15 p.m. to 6:45 p.m.

CINCINNATI
April 22 . . . L. A. Bauer, highway engineer and **J. B. Sheblessy,** highway planning of the City of Cincinnati.—"Highway Planning in the Cincinnati Area." Engineering Headquarters. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Features: Coffee talk; **Raymond Clift,** Greater Cincinnati Safety Council.

CLEVELAND
April 15 . . . Annual Student Banquet. **Lt. Col. M. G. Bekker.** —"Off-the-Road Locomotion."

DAYTON
April 16 . . . S. L. Milliken, Cadillac Motors, Detroit.—"Automotive First in Cadillac Brougham." Dinner 6:30 p.m. Meeting 7:30 p.m.

DETROIT
April 29 . . . Regional Activity—Toledo. Tour: 2:30 p.m. to 5:00 p.m. Turboglide Automatic Transmission Plant, Chevrolet Motor Division, GMC, Toledo. Reception: 5:30 p.m. to 6:15 p.m., Commodore Perry Hotel, (sponsored by Toledo companies). Dinner: 6:30 p.m., Commodore Perry Hotel. Dinner Speaker: **Dr. Kevin C. McCann,** president, Defiance College (to speak in a light vein on his duties in Washington on special assignment to the President, writing speeches, etc.) Suggested Subject: "Radiation Treatment of Fuels for Super Octane." Speaker from Gulf Refining Co. or Sun Oil Co.

METROPOLITAN
April 25 . . . Passenger Car and Body Activity Meeting. **Pete DePaolo,** Ford Motor Co.—"Ford's 50,000 Mile Run." The Engineering Societies Building, 5th Floor, 29 West 39th Street, New York. Meeting 7:45 p.m.

MID-CONTINENT
May 3 . . . Ladies Night, Sports Car Show and Road Racing Films. Tulsa Country Club, Tulsa, Okla. Dinner 6:30 p.m.

MILWAUKEE
May 3 . . . Marvin W. Dundore, assistant chief engineer, Hydraulics Division, Twin Disc Clutch Co., Rockford, Ill.—"Converters Can be Different." **David W. Eddy,** A. C. Spark Plug Engineering Staff, Division of GMC. Movie and discussion of Spark Plugs. Bohemian Club, Racine, Wisc. Dinner 6:00 p.m. Meeting 7:00 p.m. Special Features: Plant tour in afternoon at Twin Disc Clutch Co., Racine, Wisc.

MONTREAL
April 15 . . . Joint Meeting with Marine Engineers and Naval Architects. **Mr. Barrett,** president, Canadian Vickers Company, Montreal. Sheraton Mount Royal Hotel. Dinner 6:45 p.m. Meeting 8:00 p.m.

NEW ENGLAND
May 7 . . . Herbert E. Bixler, assistant to president, Northeast Airlines, Inc., Logan International Airport, Boston, Mass.—"The Economics of Competition in Transportation." M.I.T. Faculty Club, Cambridge. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: President's Night. **W. Paul Eddy,** 1957 SAE President. Social Hour sponsored by **Mack Truck, Inc.** and Shell Oil Co.

PITTSBURGH
April 23 . . . Student Night. Webster Hall-Mellon Institute. Dinner 6:00 p.m. Meeting 8:00 p.m. Special Features: Best Technical Paper. Competition between Engineering Students, University of Pittsburgh and Carnegie Institute of Technology.

SAN DIEGO
May 6 . . . R. T. Jackson, sales engineer, Manufacturer's Division, Perfect Circle Corp., Hagerstown, Ind. — "Indianapolis Racing Car Design." Special Feature: Color and sound film of the 1956 Indianapolis race—"500 Miles To Go."

SOUTHERN CALIFORNIA
April 15 . . . Aircraft Panel Meeting.—"Tooling Trends on Supersonic Aircraft." Panel Leader: **H. E. Herdrich,** director of master planning, Northrop Aircraft, Inc., Hawthorne. Panel Members: **J. A. Millsap,** chief, manufacturing methods & research, Chance-Vought Aircraft, Inc., Dallas. **A. K. Beer,** chief tool project engineer, Douglas Aircraft, Inc., El Segundo. **John Story,** tool engineer, North American Aviation, Inc., Inglewood. **R. F. Hurt,** chief tool engineer, Lockheed Aircraft Corp., Burbank. Ethyl Corporation Auditorium, 1141 Huntley Drive, Los Angeles, 7:30 p.m. to 9:30 p.m.

April 29 & 30 . . . Automotive Seminar: "Off-the-Highway Equipment." Papers will be presented by representatives of the Department of Public Works, State of California; Department of Water and Power, City of Los Angeles; Caterpillar Tractor Co.; LeTourneau Westinghouse Co.; Allis-Chalmers Mfg. Co.; and Euclid Division of General Motors. General Petroleum Auditorium, 612 South Flower Street, Los Angeles. 7:30 p.m. to 10:30 p.m.

May 13 . . . Aircraft Dinner Meeting.

TEXAS GULF COAST
April 12 . . . Frank A. Suess, manager, Continental Oil Co., Houston.—"Automotive Maintenance." Valian's, Houston. Dinner 6:45 p.m. Meeting 7:45 p.m. Special Features: This will be an audience participation type meeting.

WILLIAMSPORT
May 6 . . . Speaker from Rocketdyne Division, North American Aviation, Inc., Canoga Park, California. Williamsport Moose Auditorium. Dinner 6:45 p.m. Meeting 8:00 p.m.

SECTIONS

April 1957

Section Headlines Local Members

"Since Central Illinois became an SAE Group in 1943, and during its subsequent development as a Section, the annual 'Member Meeting' has been a regular part of its program." This was the opening statement of a discussion presented by William J. Lux, supervisor, engineering development, engineering department, Caterpillar Tractor Co. before the SAE Sections Committee at the Annual Meeting in Detroit.

During the 14 years, the custom has grown to be one of the most valuable activities of the Section. This is borne out by the fact that these "Member Meetings" consistently attract better than average attendance.

Each year, two or three people are invited to present papers at the "Member Meeting." The papers are set at 20 minutes in length, and are not limited in subject matter. Topics are usually unrelated, but the program may also be a symposium made up of related papers.

According to Lux, the program has been extremely rewarding. In addition to the individual benefits, the Section profits, too. It has been found that membership growth is proportional to the interest and activity of members. The "Member Meeting" goes right along with the Section's annual Earth-moving Industry Conference in stimulating members and keeping them active.

On the question of cooperation, Lux stated that many of the papers are volunteered. Although the Section, as a whole, is primarily concerned with one or two principal fields, the subjects covered show interesting variety. Topics have ranged in complexity from a simple capscrew to a complete diesel engine. Members have described theories and discussed field use of a finished product. Some of the material was from local industries while other papers reported activity from as far away as Hawaii and the South Pacific. One paper discussed an engineering business from over a half century ago; another paper predicted future developments. One speaker was starting engines at 65 deg. below zero, while another was heat treating metal at 1500 deg. F.

What this is indicative of is that local activities offer a wealth of material which is often overlooked, and while that material may be based on a limited interest, it will provide an interesting variety of subjects, and will serve as a good vehicle on which local membership can try its wings.

From experience, Central Illinois Section shows that the "Member Meeting" is one of those occurrences where everybody wins—and the Section recommends it most highly.

Mohawk-Hudson

I. L. Barger, Field Editor

The Section is now one podium richer thanks to **Robert McRobbie**, divisional marketing assistant, Socony Mobil Oil Co., Inc. McRobbie recently presented to the Mohawk-Hudson Section a beautiful custom-made podium bearing the SAE emblem and equipped with reading light and extension cord.

ST. LOUIS

F. H. Myers, Jr., Field Editor

Multi viscosity oils was the subject of St. Louis Section's Feb. 12 meeting. Speaker for the occasion was **J. M. Miller**, director of Automotive Division, industrial sales technical department, Standard Oil Co. of Ind.

According to Miller, oils with V. I. improvers tend to reduce wear, decrease oil consumption, improve gas mileage, facilitate starting in cold weather, alleviate rust and corrosion, and control carbon formation more effectively.

CINCINNATI

A. R. Ehrnschwender, Field Editor

Over 100 members and guests of the Cincinnati Section heard **Norman R. Parmet**, director, aircraft development, Trans World Airline, Inc., discuss "The Passenger Factor in Jet Transportation Equation."

Those attending also were treated to a film, "Mr. Withers Stops the Clock" which dramatizes the importance of air transportation to the life and economy of the nation.

Philadelphia

E. V. Henc, Field Editor

"Developments on Off-Highway Vehicles" was the paper presented at the Philadelphia Section's February meeting by **E. K. Sternberg**, special project engineer, Autocar Division, White Motor Co.

Preceding the talk, **Carl C. Saal**, chief, vehicle operations section, Department of Commerce, Bureau of Public Roads, Washington, D. C., gave a report on President Eisenhower's multi-billion dollar highway program and the effect it will have on the manufacturers of heavy earth moving equipment.

Section Holds Annual Aircraft Production Meeting

TEXAS

R. N. Williams



Preparing for the program of the Texas Section on aircraft production are Meetings Chairman Robert L. Lemon (standing), and principal speakers Gen. Joseph T. McNarney (left), president of Convair Division, General Dynamics Corp., and Maj. Gen. David H. Baker (right), U. S. Air Force, director of procurement and production.

Approximately 200 engineers, mainly representing aircraft production and engineering officials from Texas and California, were on hand for one of the most successful sectional programs on aircraft production ever sponsored by the Texas Section.

The Section's annual Aircraft Production Meeting on March 8 held two high-spots of interest for those in attendance—the U. S. Air Force policy governing procurement, and a search for management's missing link.

Need for a whole new segment of scientist-engineers to more closely integrate aircraft design, development, and manufacturing processes was pointed up by **Gen. Joseph T. McNarney**, president of Convair Division, General Dynamics Corp.

Maj. Gen. David H. Baker, director of procurement and production of the Air Force's Material Command, Wright Patterson Air Force Base, outlined the AF's current policy as to the extension of the "complete weapon system" to the growing emphasis on missiles.

The history of Bell Aircraft's helicopter development was outlined by **Bartram Kelley**, chief engineer of Bell Helicopter Corp., Hurst, Tex. He documented his talk with a chronological film which began with early experiments in 1930.

E. H. Simpson, manager of production engineering, Hughes Aircraft Co., Culver City, Calif., discussed the increasing demands on electronics systems. He presented slides illustrating steps his company has taken to keep pace with needs and also to economize on plant space for the relatively high proportion of testing space with relation to production.

The comprehensive program was arranged by **Robert L. Lemmon**, production engineer of Convair Fort Worth Division. This was Lemmon's first year as chairman of the Aircraft Production Meeting.

BUFFALO

S. E. Leese, Field Editor

A timely review of air suspension systems as applied to passenger car and truck service was presented before the Buffalo Section at the February meeting. This discussion was headed by **Harry Elkin**, research engineer, American Motors Corp., and **Herbert Deist**, assistant manager, engineering laboratory, Firestone Tire and Rubber Co. Both men have specialized in this application of air suspension systems.

Interest in the topic was displayed by the members and guests, numbering over 100, during the lively question and answer period that followed the talks.

Highlight of the Feb. 5 meeting of the Buffalo Section's Rochester Division was a paper on automotive fuel injection by **Donald Stoltman** of the Rochester Products Division, General Motors Corp.

The many questions and comments brought forth from the floor indicated great interest in this subject. Further evidence of the lively interest in this topic was the fact that this meeting attracted 125 members and guests.

Available for examination and discussion were an automotive fuel injection system and two automobiles, a Chevrolet and a Pontiac, which were equipped with fuel injection systems.

No. California

C. W. Dunbar, Field Editor

Students Compete in Safety Economy Run



College students and SAE observers prepare for the Mobilgas Safety Economy Run sponsored by the Northern California Section and the South Bay Division.

Focal point of the joint annual student meeting of the Northern California Section and the South Bay Divison on Feb. 27 was the Mobilgas Safety Economy Run. Participants in the event were students from the University of California at Berkeley, San Jose State College, and California State Polytechnic College.

Fifteen entrants from the above schools competed for trophies given for best overall miles per gallon.

A highway course off 88 miles in the bay area was logged by the California Highway Patrol and California Automobile Association for the run. An average speed for the course was determined and each car was required to cover the course in a reasonable amount of time. An SAE member observer was present in each automobile entered.

At the evening meeting, members and guests heard **Ray Burton** of General Petroleum speak on "Save Gas and Maybe Save a Life."

Trophies were also presented at the meeting in two catagories—ton-mpg and best overall mpg.

In the ton-mpg category winners were Herbert J. Brunner, California Polytechnic College, with a 54 ton-mpg record in a 1949 Ford V-8, Maynard Smith, California Polytechnic College, with a 52 ton-mpg record in a 1956 Triumph TR-3, and Harry Sheid, California Polytechnic College with a 48 ton-mpg record in a 1951 Studebaker.

Winner of the overall best mpg category was Maynard Smith, California Polytechnic College with a 44.1 mpg record in a 1956 Triumph.

From Student Cameras







1. **J. A. Bolt** (left), past-chairman of the SAE Student Committee talks shop with **L. L. Otto**, 1957 chairman of the SAE Student Committee at the Annual Meeting in Detroit.

2. **Jean Buhler** (right), chief naval architect, Miami Shipbuilding Corp., who spoke on "Hydrofoils—Boats that Fly" at the University of Miami SAE Student Branch, is shown discussing his subject with **John D. Gill** (left), assistant professor of mechanical engineering at the university, and faculty adviser for the branch.

Films on the developments of Hydrofoils were also shown to the students.

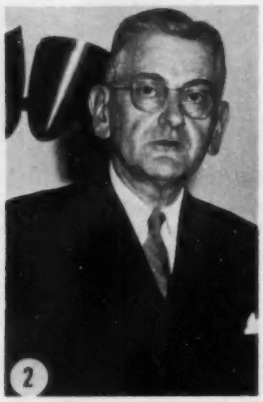
3. University of Detroit SAE Student Branch members were treated to a panel discussion on the career opportunities in the fields of civil, mechanical, chemical, electrical, and industrial engineering at the Feb. 23 meeting.

Panel members are left to right: **Larry Martin**, Michigan State Highway Department; **Prof. Loren Knowles**, Lawrence Institute of Technology; **William McCarthy**, Ford Motor Co.; **Philip Bowser**, Chevrolet Division, General Motors Corp., **William Cawthon**, Dodge Main Plant, Chrysler Corp.; and **Edward Slagis**, Student Branch chairman.

From Section Cameras



1



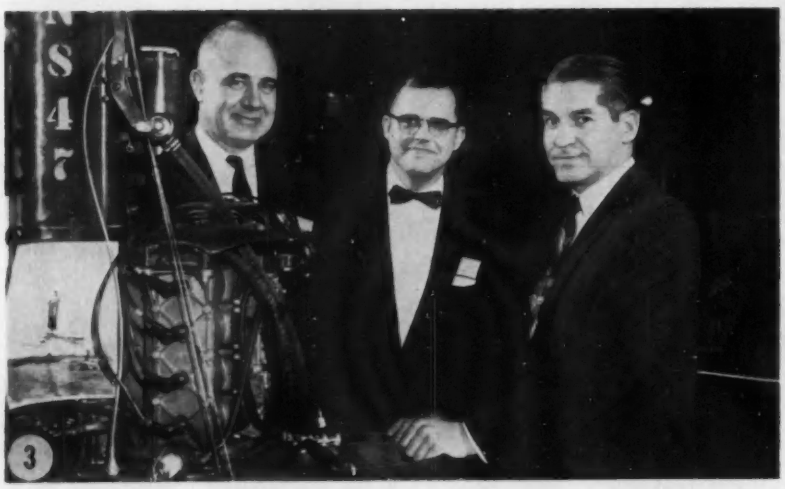
2

1. Examining a cutaway model of a free piston engine at **Pittsburgh Section** Feb. 26 meeting are main speaker **Warren H. Smith** (left), supervisor, mechanical development department of the General Motors Corp. Research Laboratories, and **Maurice J. Boegel** (right), Gulf Research and Development Co.

Smith supplemented his talk on "The Free Piston Story" with a short motion picture showing the fabrication and assembly of a free piston engine as well as the installation of the unit in a car.

2. Members and guests at the Feb. 13 meeting of the **Twin City Section** enjoyed a talk on "Development and Characteristics of Disc Type Brakes" presented by **C. L. Eksergian,** executive engineer and assistant to the vice-president, the Budd Co.

Following the meeting, a short film on the disc brake was presented.



3

3. Inspecting the DeLackner "Helivector" at the February meeting of the **Dayton Section** are left to right: **Mearick Funkhouser,** Section chairman; **James H. Roberts,** Section vice-chairman; and main speaker **Donald DeLackner,** president of DeLackner Helicopters.

DeLackner explained to those present the function of this unique craft in his paper, "The Helivector—the One Man Helicopter."

4. Special feature of the meeting was the presentation of plaques, honoring three members of the **Dayton Section** for a combined total of 95 years of membership in SAE.

Membership Chairman **George W. Heck** (left) congratulates 35-year member **Garnet C. Brown** (center) and 25-year member **George A. Page, Jr.** (right) as they receive their membership plaques. Also honored for 35 years of service to the Society was **Karl W. Stinson.**



4

5. Guest speaker at the San Diego Section's April 4 meeting was **Krafft A. Ehricke,** chief of preliminary design and systems analysis, Convair Division, General Dynamics Corp. Ehricke is internationally known for his contributions to the theory and practical application of methods of travel to and in outer space.



5

DETROIT

G. J. Gaudaen, Field Editor



Three Ring Circus Featured in Detroit

"The Three Ring Circus Meeting" (multiple paper meetings to the uninitiated) has become a popular phase of Detroit Section life.

The Section has found separate sessions on diverse subjects to be an effective method of accommodating the wide variety of automotive engineering interests found among the members.

The second one of the year was held on Feb. 18 with three separate sessions sponsored by the Truck and Bus Activity, the Engineering Materials Activity, and the Body Activity.

1. Section Chairman Charles Dybvig joins the coffee speaker Jack Alan of K.L.A. Laboratories, Inc., who spoke on "Hi-Fi Rama—The History of Recorded Music."

2. Members of the Truck and Bus Activity session are shown from left to right: K. A. Beier, Schwitzer Corp.; T. A. Robertson, Firestone Tire and Rubber Co.; and W. A. Bonvallet, General Motors Corp. Proving Ground. Topic covered by the trio was "The Ins and Outs of Truck Noises."

3. Chairman of the three Activities participating in the February Three Ring Circus are left to right: Joseph Gurski, Engineering Materials Activity chairman; R. R. Noble, Truck and Bus Activity chairman; and W. K. Norwick, Body Activity chairman.

4. Speaker for the Engineering Materials Activity Session was Frederic S. Altman, Fisher Body Division, General Motors Corp., who discussed "Techniques and Materials for Low-Cost Tooling."

5. "Trends in Body Types" was the general subject for the Body Activity Session. Speakers are left to right: George F. Macfarlane, Ionia Mfg. Division: Sydney L. Terry, Engineering Division, Chrysler Corp.; and Ben J. Smith, Lincoln Division, Ford Motor Co.

From Section Cameras



1. **G. E. Burks** (center), technical chairman for **Central Illinois Section's** Jan. 28 meeting, greets speaker **C. G. A. Rosen** (right), consulting engineer to the president, Caterpillar Tractor Co. and SAE past-president, while Section Chairman **R. D. Henderson** (left) looks on.



2. Officers of the **Texas Gulf Coast Section** gather with honored guests at the Section's February meeting. Left to right are: **John Payne,** Shell Development Co.; **Roy E. Edwards,** technical chairman for the meeting; **Bruce G. Collip,** Shell Development Co., who discussed "Offshore Mobile Units—Present and Future"; **R. F. Wilson,** Section vice-chairman; and **W. B. Tilden,** Section secretary.

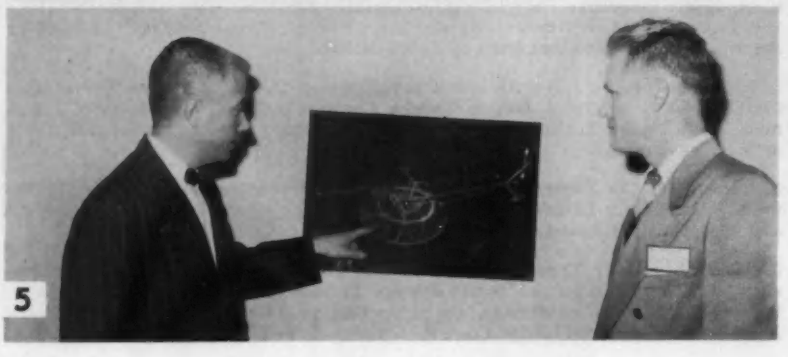


3. This informal photo catches a glimpse of the **Texas Gulf Coast Section** Governing Board as they pore over Section business. Left to right are: **R. E. Edwards, B. F. Denny, R. F. Wilson, W. B. Tilden, A. C. English, William Fortenberry, C. F. Goff,** and **Luke Johnson.**



4. Principals at the joint meeting of **SAE Williamsport Group** and Williamsport Chapter of the American Society of Tool Engineers pose for this Journal photograph. Left to right are: **Blair S. Kratzer,** Williamsport Group Meeting chairman; guest speaker **Sears Williams,** Glenn L. Martin Co.; **Donald Smith,** Williamsport High School Science Club guest; **Allen Weiss,** Williamsport Group chairman; and **Dale L. Chubb,** president of Williamsport Chapter American Society of Tool Engineers.

Subject discussed at the meeting was "Project Vanguard," the launching of the first man-made earth satellite.



5. **Wayne Wiesner,** Hiller Helicopters, Inc., is shown here explaining helicopter designs at the **Northern California Section's South Bay Division** March 5 meeting, while Division Program Chairman **Claude Hess** looks on.

Movies were shown of late model helicopters undergoing tests as well as the Hiller "Flying Platform" both in the air and on the ground.

MONTREAL

A. A. Larkin, Field Editor

February 18 brought the annual joint meeting of the Montreal Section with the Canadian Aeronautical Institute. Featured speaker was **Arthur C. Johnson,** projects manager, Nuclear Division, Canadair Ltd, who delivered a talk on "Progress Report on Nuclear Power."

About SAE Members

Continued from page 97

MAX B. SHIPLEY has joined the research department of Caterpillar Tractor Co. as a junior laboratory engineer. Previously, he was a dynamometer operator for Massey-Harris-Ferguson, Inc.

JACK S. MILLER is now an experimental test engineer with the Pratt & Whitney Division, United Aircraft Corp. Formerly, he was a project engineer, Fuels and Lubricants Division, Southwest Research Institute, San Antonio, Texas.

ALFRED A. RAPPUHN, sales manager for Elo Development Co., Inc., Long Island City, N. Y., has been named a vice-president of the company.

S. D. DEN UYL, president of Bohn Aluminum & Brass Corp., has been elected president of the Aluminum Association.

EVERETT G. FAHLMAN, president of the Permold Co., who served as president of the Aluminum Association for the past two years, was elected chairman of the board for the association.

WILLIAM S. KASKA has been made district manager, Texas area, Titeflex Inc. He formerly was a sales engineer for Titeflex.

ROBERT A. SCHMICKER is new manager, Oversees TBA Section, Esso Standard Oil Co. Prior to joining Esso, he was a tire engineer for Atlas Supply Co.

WALLACE H. NICHOLS has been made vice-president, Rand Development Corp., Cleveland. He formerly was chief engineer, H. J. Rand and Associates, Cleveland.

RAYMOND P. RANTA is now a liaison engineer with Scott-Atwater Mfg. Co., Minneapolis. Previously, he was a manufacturing liaison engineer with Reo Motors, Inc., Lansing, Mich.

ALAN R. COLLINS has joined the Investo Mfg. Co., Pty. Ltd., New South Wales, Australia. Formerly, he was managing director, Stancast Pty. Ltd., New South Wales.

J. L. S. SNEAD, JR., president of Consolidated Freightways, Inc., has announced the purchase of the assets, including operating equipment and terminals in Alaska, of Garrison Fast Freight, Inc., by Consolidated Freightways.

RICHARD J. MEINERT has been named manager of the Chicago branch, Central Division, Mack Trucks, Inc. For the past four years he has been Cincinnati branch manager for the company.

RICHARD BLAKLEY has been made senior engineer, product engineering, missile operations, Chrysler Corp. Formerly, he was in engineering parts follow-up, Engineering Division, at Chrysler.

PHILIP F. WEBER, formerly factory manager for Kollsman Instrument Corp., a subsidiary of Standard Coil Products Co., Inc., has been appointed assistant to the president at Kollsman.

Weber will be responsible for monitoring production, providing interdepartmental liaison, and maintaining central analysis for all instrument systems.

He joined Kollsman in 1935 as project engineer and became factory manager in 1945.



YA® Radiators

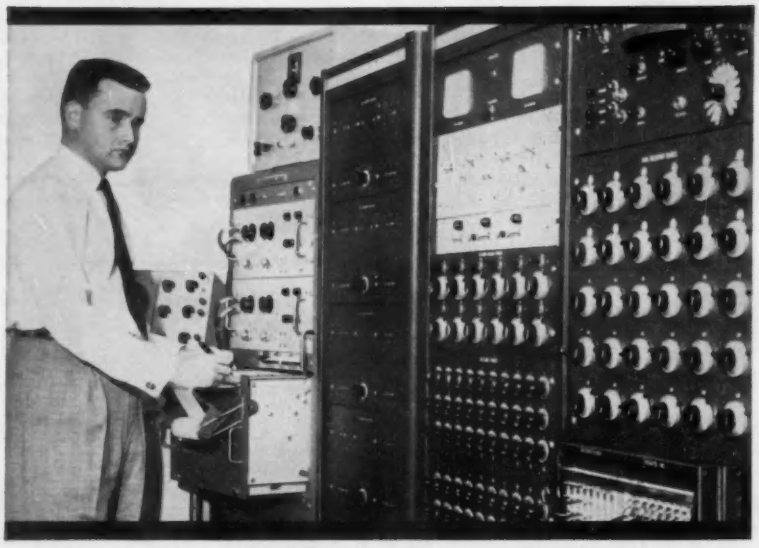


Industrial trucks on daily duty take a lot of heavy load punishment . . . and these hard working engines demand a rugged-built, efficient radiator to do the cooling job. That's why more and more manufacturers of motor trucks, tractors, compressors, and locomotives are specifying YA Radiators . . . for they know YA quality and performance! Write to day for complete information on YA radiators designed in cooperation with your engineers to fit your specific needs.

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Analytical Engineers



Marquardt engineers work their own problems on this electronic analog computer.

Marquardt offers opportunities in the field of supersonic propulsion

To solve the complex problems of supersonic and hypersonic propulsion, Marquardt needs analytical engineers capable of independent and original work.

To encourage a creative climate Marquardt provides modern facilities such as our Analog Computer which enables engineers to investigate parametric solutions to these problems.

The Marquardt computer room contains two separate differential analyzers which may be used separately or together. These computers are designed so that you may set up your problem and obtain a solution either personally or with the services of a computer specialist. Problems which heretofore required many tedious hours are now run-off from four milli-seconds to several minutes depending on the time scale chosen.

Operating with a real time scale, the analog computer may be used as a simulator in conjunction with other components of the physical system. Such an application saves hours of valuable design, building and test time.

You will find a variety of challenging problems at Marquardt. Problems involving control components, or complete ram-jet, turbo-jet and inlet control systems, are but a few.

If you would like to participate, please write or phone:

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CEP News

Continued from page 86

for an over 400 F fluid at this time.

The remainder of the Brake Fluid Spec will follow closely the present 70R1 requirements covering high and low temperature viscosity, water tolerance, neutrality, corrosion, cold tests, compatibility with other fluids, residue, evaporation, rubber swelling, and lubrication.

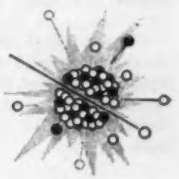
New Fluids Bring New Concepts and Questions

Lubrication requirements differ in high temperature fluid formulation. 20% to 40% lubricant may be needed to satisfy lubricating requirements in new fluids pushing 400+ F.

High temperature surge tests are needed on brake cups to see how many elevated temperature stops can be made before cup failure.

Evaporation test temperatures and percent of residue of future high temperature fluids will require a new look. At present, 70R1's maximum evaporation at 210 F is 80%.

nuclear news notes



reported by
SAE NUCLEAR ENERGY ADVISORY COMMITTEE

NUCLEAR radiation will replace heat in vulcanizing rubber and will produce longer-lasting tires to boot. That's what B. F. Goodrich scientists found in developing a commercially feasible method for vulcanizing rubber using nuclear vulcanization.

Normal vulcanization calls for the addition of sulfur and other chemicals to the rubber and then heating it. This creates a carbon atom chain with the sulfur atoms serving as the links. Trouble is that these sulfur atoms are weak links in the chain.

Nuclear vulcanization permits the carbon atoms to be linked together directly, without sulfur or accelerators.

Goodrich reports that nuclear vulcanized tires have much better resistance to aging and deterioration. Treads wear longer. The company also says that with nuclear energy, tires could be vulcanized cold much more rapidly on the production line. Current process requires heat above 300 F.

The development work on this new process was done at the Atomic Energy Commission's National Reactor Testing Station in Idaho. In commercial production, the process can be performed using one of several radiation sources. One source would be radioactive waste materials which create a serious disposal problem today.

Reducing Man-Hours Lowers Airplane Cost

Based on paper by

K. B. BINGHAM
Douglas Aircraft Co., Inc.

AIRPLANE COST and man-hours are practically synonymous.

Reduced man-hours permit a greater number of aircraft to be produced in a given time. And since aircraft cost and man-hours are basically one and the same thing, a designer directs his efforts towards a design that reduces man-hours. He does this by:

1. Designing so that a man can do a job that he has done before (carry-over).

2. Designing so that a man does a job he can understand.

3. Designing so that a man can correct for errors by making the structure repairable.

4. Designing to compensate for tolerance and temperature effects by providing take-up provisions in the design.

5. Designing a set of fits and tolerances that are both realistic and compatible with design quality.

(This article is based on one of five papers presented by a panel on "Control of Manufacturing Costs." Other speakers were: **J. D. Fast,** Lockheed Aircraft Corp.; **T. D. Seeger,** North American Aviation, Inc.; **L. K. Pratt,** Ryan Aeronautical Co.; and **D. J. Thornton,** Solar Aircraft Co. The report of this panel is available in full, together with reports of thirteen other panel sessions of the SAE Aircraft Production Forum. This publication, SP-317, is available from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

High-Speed Flight Influences Fasteners

E. O. BAUMGARTEN
North American Aviation, Inc.

SUPERSONIC aircraft are being designed with as few fasteners as possible so as to reduce the incidence of failure. At the same time, new types of fasteners, materials, and standards are being sought.

Materials are available in large variety, the majority of them corrosion resistant. It is important that the material selected be compatible with the service environment. One should know, for instance, for how long a time the fastener will be subjected to elevated temperatures. Some fasteners may be satisfactory for a short time span, but not for a long one. Some materials are more efficient structurally at extremely high rather than medium temperatures.

Titanium appears to be a good fastener material and is here to stay. It has the best strength/weight ratio. Customers demands are now being met and larger quantities will be available in the near future. The difficulties that are had with titanium bolts galling in thread engagement may be overcome by using cadmium-plated steel nuts. Conventional titanium rivets will require hot driving.

Blind self-sealing fasteners are now in demand. Requirements are that they be easy to install, have the ability to seal, and are structurally efficient. They should, in fact, be as good structurally as non-blind fasteners. No standard self-sealing blind fastener now exists.

The quantity of bolts required in



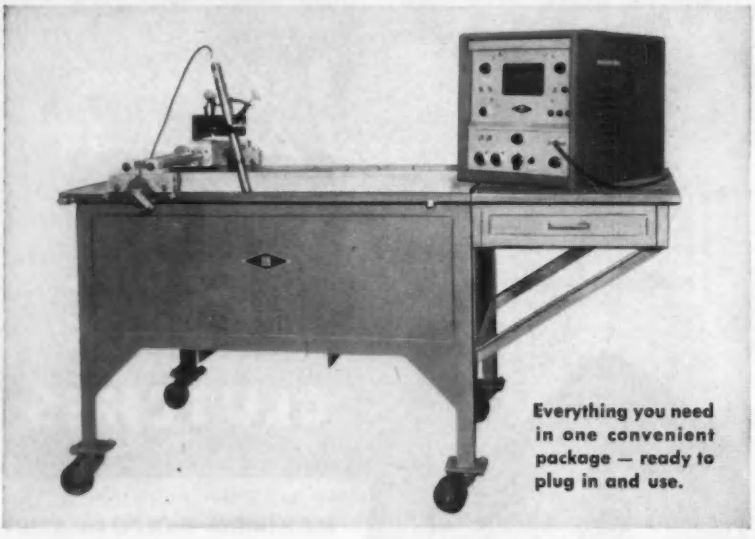
some doors and panels makes quick unfastening impossible. There is need for a semi-quick-release, high-strength fastener for use on stressed doors. Release would be accomplished by rotation of the stud 180 to 360 deg rather than the 90-deg specification requirement.

Through the cooperative effort of the Military and the aircraft and fastener industries, complete new families of fasteners are being developed. And the speed of advance is such that yesterday's special fastener is today's standard. Highlights of this activity include: standardizing on 160,000-psi minimum strength screws and bolts; low-height nuts developing the same strength as the present nuts; a series of miniaturized plate nuts; development of high-torque driving recesses or slots; 180,000 psi, 12-point external wrenching head bolt; a series of titanium fasteners; a design standard for fastener shank diameters and installation hole sizes; a standardization of blind rivets; and a high-strength quick-acting rotary fastener.

Attention is now being called to the need for a new approach to testing. The suggestion is to develop performance curves rather than use finite numerical ratings, particularly for short-time performance in extreme environments.

(This article was based on the secretary's report of the panel on Fasteners. Panel leader was W. T. Barker, North American Aviation, Inc.; co-leader was J. W. Evans, Aircraft Laboratory, W. A. D. C.; secretary was E. O. Baumgarten, North American Aviation, Inc. Panel members were: W. A. Bratton, Convair Div., General Dynamics Corp.; E. F. Hagar, Lockheed Aircraft Corp.; A. S. Leipsig, Douglas Aircraft Corp.; L. Olason, Boeing Airplane Co. This report together with 13 other panel reports is available as SP-317 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $2.00 to members; $4.00 to nonmembers.)

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Older Aircraft Will Tap New Market

Based on paper by

E. A. CARTER
Curtiss-Wright of Canada, Ltd.

WHEN turbine-powered aircraft are carrying all the first-class and tourist-class air traffic available, the existing piston-engine transports could well be put to work opening up a third class of service at 2½¢ or even 2¢ a mile.

Table 1, which presents an economic comparison between the depreciated

Table 1—Depreciated Reciprocating-Powered Aircraft versus Typical Medium Jet Liner (300 statute mile range)

	Reciprocating	Jet
Direct Operating Cost, $/mile	1.21	1.73
Indirect Operating Cost, $/mile	1.21	1.73
Total Operating Cost, $/mile	2.42	3.46
Block Speed, mph	263	354
Total Cost, $/hr	636	1225
Revenue, $/hr at 65% load factor	646	1220
Revenue Income, $/hr at 65% load factor	10	(5)
Utilization, hr/yr	3000	3000
Revenue Income, $/yr at 65% load factor	30,000	(15,000)

Note: Figures in ( ) indicates loss.

reciprocating-powered aircraft and a typical medium jet liner, substantiates the suggestion for third-class travel.

The airlines of North America are now reaching approximately 15% of the total population. Passengers can be divided into business and tourist types. Of the tourist type, about 5% of the population of any particular metropolitan area has been reached. Third-class travel would mean reaching thousands more from any one of these areas, since such travel would then be lower in cost than bus, train, or shipboard. Regional and local service airlines will also be a ready market for the depreciated aircraft with its low break-even load factor and its ability to use short runways close to town.

Third-class travel will come from good planning and foresight on the part of airline executives. It will constitute a standby or third coach traffic, available on a commuter-style basis especially for those who cannot afford, or do not wish to pay, first-class or tourist-class fares. This new class of traffic would require a radical revision of the air fare rate system of any scheduled airline, but it is feasible and practical.

(Paper, "The Place of the Reciprocating Engine In The Jet Age," was presented at SAE Montreal Section. It is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Ball Bearing Motion Undergoes Visual Study

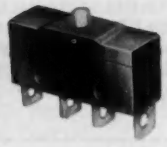
Based on paper by

R. P. SHEVCHENKO
and
P. BOLAN
Pratt & Whitney Aircraft, Division of United Aircraft Corp.

THE motion of the ball in ball thrust bearings operating at high speed has been under study. The ball motion is being recorded photographically, then analyzed to determine what forces affect it.

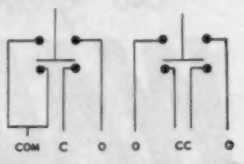
The preliminary test results are not conclusive. A discrepancy has been found between results and the predicted values in the cases of direct measurements of cage and ball speeds. This suggests the desirability of reexamining the cage speed-load relationship in the region where the discrepancies exist. A difference between the predicted and calculated test contact angles suggests the lack of a com-

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Write for literature, engineering data!



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In Canada: Robertshaw-Fulton Controls (Canada) Ltd., Toronto

plete understanding of the motion of a ball in a bearing. If the predicted motion is in error, then the internal forces and their effect on bearing life might not have been accounted for completely.

(Paper, "A Visual Study of Ball Motion in a High-Speed Thrust Bearing," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Lear Autopilot Has Four Loops

Based on paper by

DUNSTAN GRAHAM
Lear, Inc.

(As reported by Kenneth Rix, SAE Wichita Section, Field Editor)

LEAR'S autopilot has a vertical gyro, a device which tends to maintain its spin axis in space and which is used through the autopilot servos to deflect the airplane's control surfaces in response to the error angles measured by the gyro.

The control-surface positioning servos are the minor loop. It consists of an amplifier, a servo, and a followup which feeds back to the input of the amplifier. The next loop is called the damping loop. The feedback from the output or airplane motion is generally picked up by a rate gyro and fed into the autopilot for the purpose of damping the oscillatory motions. Then there is the attitude stability loop, representing the feedback to the vertical gyro.

The final loop may be a path control loop, altitude control, control to a VOR beam, control to a localizor or glide path, or in some weapon systems might be a weapon aiming system.

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Cessna 620 Aims At Corporate Market

Based on paper by

DWANE L. WALLACE
Cessna Aircraft Co.

THE Cessna 620 is a low-wing, tricycle geared, 4-engine pressurized private airliner. It seats five passengers but will carry as many as nine if the occasion demands. Fuel capacity of 535 gal gives it a range of 1700 miles.

The 4-engine concept was accepted for safety reasons and flat engines were designed into the wing with all fuel positioned outboard of the inboard engines. Ruggedness was obtained without excessive weight due to weight distribution with the 4-engine tip-tank configuration.

Seats and cabin furniture are attached to full-length seat tracks with 1-in. increments for quick rearrangement or removal. If needs be, cargo can be anchored to the seat track. There is a full-size lavatory, coat closet, and luggage compartment. Aft of the flight deck there is an electric buffet convenient to crew and passengers. A self-contained folding stairway is part of the cabin door.

To make the airplane highly self-sufficient, an air-conditioning and heating unit is supplied which is powered by the gas turbine pressurization unit operating with complete independence of external power facilities. Electrical power supply is also supplied through the gas turbine.

Short field performance was another important consideration in the design of the 620. This will permit using the

nation's 7000 airports, not to mention the 550 served by the airlines.

(Paper, "A Manufacturer's Philosophy of Meeting Today's Business Air Transport Requirements," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Better Headlighting Depends on Better Aim

Based on paper by

V. J. ROPER
General Electric Co.

THE new dual-unit headlamp system adopted on 1957 model cars is only as good as the correctness of the aiming. This is true, as well, of any headlamp system.

To provide seeing distance equal to or in excess of stopping distances, the headlamps must be aimed within very close tolerances of exactly correct aim. Mis-aim can mean reduction of seeing distance to the point where a pedestrian is not seen in time to stop, or not seen at all. And the vision of the oncoming driver is also impaired.

The aiming process has been improved and simplified by adding accurately aligned aiming pads on the front surface of the lens. During manufacture and assembly of sealed-beam headlamps, the front surfaces of these pads are accurately placed with respect to the aim of the beam. They permit the use of simple, mechanical aiming devices which are relatively inexpensive and easy to use.

(Paper, "Aiming For Better Headlighting," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Lubricant Affects Octane Requirement

Based on paper by

F. S. WOOD
and
C. C. COLYER
Standard Oil Co. (Indiana)

THE octane requirement of an engine to suppress either spark knock or audible surface ignition is influenced greatly by the motor oil used. But multigraded oils are not necessarily more effective in reducing octane requirement than single-graded oils. Much depends on the base oil and the viscosity index improver.

A modified detergent with a specific viscosity index improver reduces both spark knock and surface ignition. If the proper lubricant is selected, engines that are surface-ignition limited can be made spark-knock limited. In field tests, although higher-speed commuter driving reduced the requirement level, the benefits of the modified detergent were found to be equivalent under both city and commuter driving.

The benefits observed in the field, expressed in performance numbers, were similar to those observed in the laboratory regardless of differences in engine design, compression ratio, and engine operation.

(Paper, "Effect of Oil Volatility and Additives on Engine Octane Requirement," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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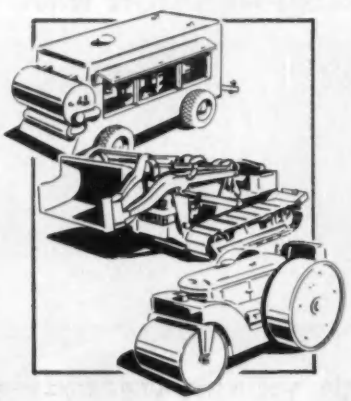
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Continental Motors Corporation
MUSKEGON AND DETROIT

Develops Fast Test For Air Seal Materials

Based on paper by **GILBERT C. BARNES and EARLE A. RYDER**
Pratt & Whitney Aircraft, Division of United Aircraft Corp.

PRATT & Whitney Aircraft has devised a rough and ready test to screen pairs of materials under consideration for rotating air seals for load-carrying ability and wear rate.

Fig. 1 shows the seal rig. The pilot piece at the left carries a standard drive gear and a shaft on which the rotating seal carrier is mounted. The stationary seal carrier sits on a ball-ended

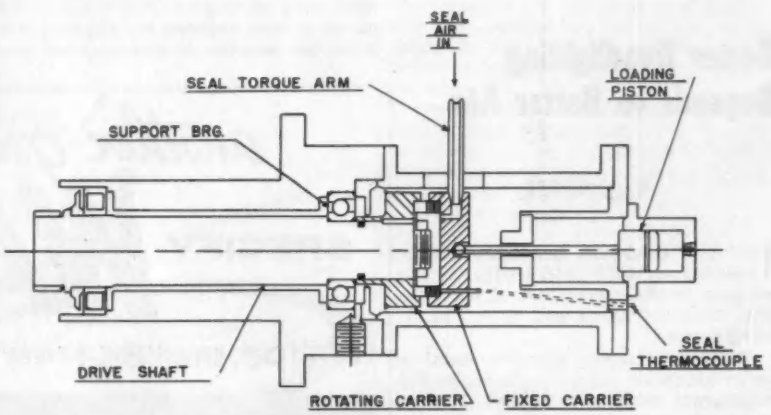


Fig. 1—Seal rig developed to afford rough and ready testing of load-carrying ability and wear rate of pairs of materials considered for use as rotating air seals.



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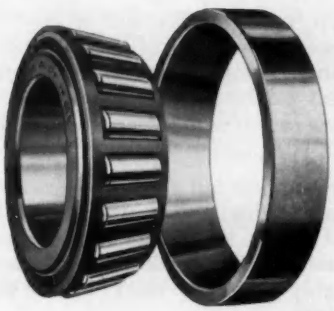
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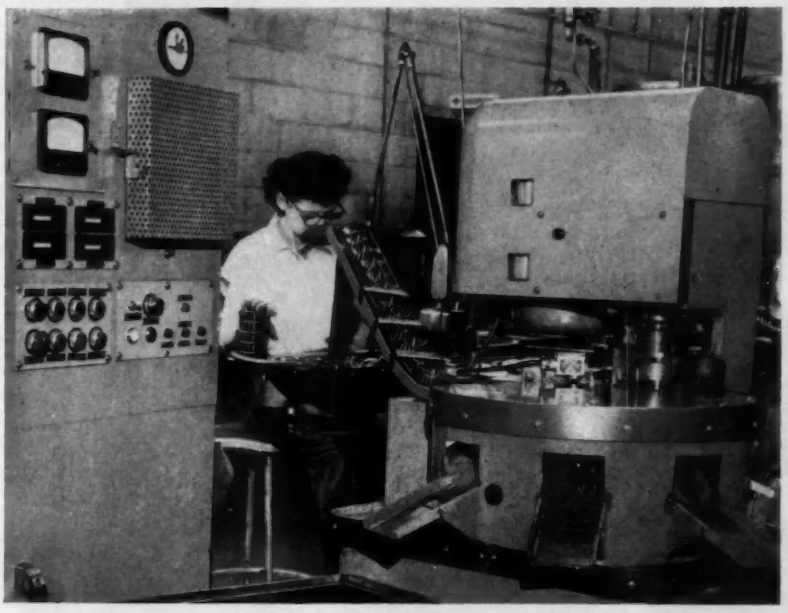
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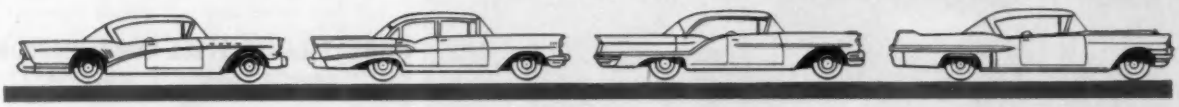
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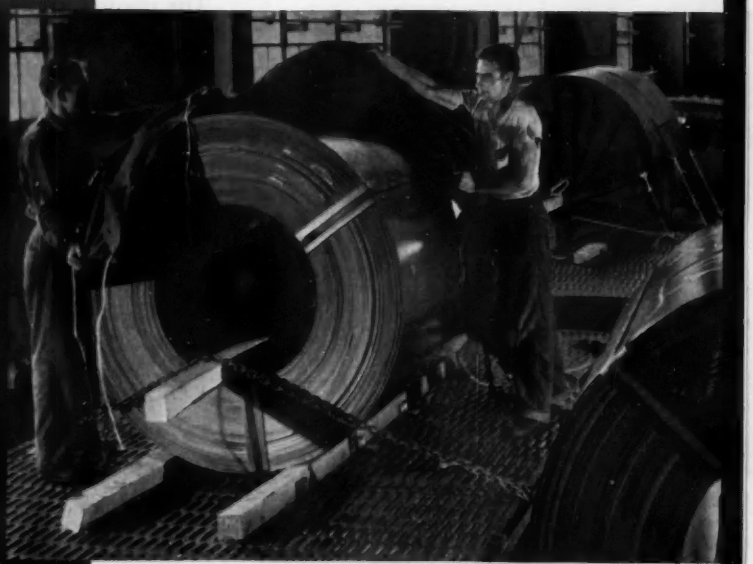
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BUILT-IN QUALITY of Great Lakes steel is guarded through every step to final delivery. Here shipments of flat-rolled sheet coils are covered with tarpaulins for protection.

rod projecting in from the right and loaded axially by a hydraulic piston. This carrier is held from rotation by the pipe which supplies the seal (leakage) air, and which also serves as a torque arm to weigh the friction torque. This torque reading has been used only to note any sudden rise in torque. Wet or dry air or other gases may be supplied to the seal.

The thermocouples are mounted in the stationary carrier touching the back of the test rig. They do not measure the temperature of the working face, but do reveal gross differences in the heat generated by friction. The seal rig is driven by a 7½-hp dynamometer through a transitorque and the stepup gear so that speeds from 4500–15,000 rpm are available. The driving torque is read on a Toledo scale and the test stopped if it exceeds a certain value. Oil pumps, tank, heater, gages, and the like are provided with controls. Seal air pressure can be varied from 0 to 100 psi and the net load on the rubbing surfaces from 0 to 100 psi.

The desirable properties for seal materials are low friction, low wear rate, low leakage rate, manifestation of all these properties at 1000 F or more, and ability to operate at high altitudes (low humidity).

Test Procedure

The test is started with 45-psi air pressure inside the seal rings and the drive shaft speed is increased from 6000 to 15,000 rpm in 30 min. The axial load is small at the start so that high air leakage results, and the load is increased gradually so that after 30 min the seal faces rub each other with a net load of 3 psi. Some poor materials score during this period of high friction and heat and the test is ended. If no trouble develops, the test continues in hourly steps with the seal (leakage) pressure reduced 5 psi and the axial load adjusted to increase the net face load by 3 psi at the end of each hour.

Each period gives the rubbing surfaces a chance to accommodate themselves to each other and reach stable conditions of friction and temperature. The heat is removed by the leaked air and by conduction and radiation to the housing of the rig. The heat generated by friction could be calculated from the torque on the fixed ring. The end point of the test is reached when one of the following conditions occurs:

1. Dynamometer torque exceeds 210 lb-in.

2. Either thermocouple back of the fixed seal exceeds 600 F for carbon mixtures, or some higher limit for other materials.

Temperature indications plot a ragged curve, generally trending slowly higher as load increases, with a sudden jump when the end point is reached. What is wanted, of course, is a pair of materials which will generate smooth surfaces to high pressures and temperatures without a catastrophic future.

In general, carbon compositions are not much good above 600 F and require cooling if they tend to run hotter than that. Different batches of carbon, nominally the same, may have quite different frictional properties. We need a specification test or tests to insure constant properties. The scatter of results on specimens taken from the same batch of material is 3–6 psi. A production type of carbon versus chrome plate (several batches) ranges from 6M to 15L. (Paper, "A Progress Report on Rubbing Seals," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Rear-Engine Car Will Be Styled Slowly

Based on paper by

BROOKS STEVENS
Brooks Stevens Associates

IF and when the American rear-engine car arrives its styling will be found to be evolutionary. To go all the way with one sweeping revolutionary change would not be acceptable to the motoring public.

Some of the characteristics of this "transitional" car will probably include the following:

Seating position will be approxi-



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Now standard equipment on thirty-seven (37) leading makes of cars, trucks, tractors, commercial vehicles, industrial and marine engines.

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Control with Dole DOLE TRADE MARK
THE DOLE VALVE COMPANY
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1908 Control with DOLE Over 50 Years of Service

mately the same as in today's front-engine car. In a sense the luggage area and engine compartment will be interchanged.

There will be some appearance of a hood or nose and fender-like enclosures beyond the windshield point. Since this area can be used for luggage and radiator grilles will have no functional purpose the area can be depressed and made infinitely better from a vision standpoint. A line from the driver's eye over the forward sheet metal to the ground will arrive at a point closer to the vehicle than in present-day cars.

The most practical version of the wraparound windshield will predominate. A softly rounded curved windshield should not merely be pushed forward on the cowl to give the illusion of wraparound or streamlining without performing its true function.

Designers will work toward maximum inside space and comfort with a minimum of outside dimension and depend heavily upon esthetic visual tricks of line and form to decrease the bulbous look. Bright metal mouldings and trim should be utilized with discretion in vulnerable points such as the rub rail area of the body side and contact members such as bumpers.

If the purely functional rear-engine car of tomorrow is to be designed in a wind tunnel, visual manufacturer identity will be hardest to retain. The fender has become as archaic as the hood or bonnet.

(Paper, "Styling The Rear-Engine Automobile" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Small Gas Turbines Ready to Win Markets

Based on paper by

SUMNER ALPERT
Solar Aircraft Co.

THE Solar Mars (50 hp) and Jupiter (500 hp) gas turbine powerplants have had their growing pains, but on the whole they have proved reliable and well qualified to compete with other types of powerplants for specialized applications.

The Mars was developed eight years ago to drive an emergency fire pump for the U.S. Navy. It featured hand starting. From the first success has sprung a line of descendants—more advanced pumps, generators, and compressed air sources.

About 650 Mars engines have been built, mainly airborne auxiliary power units (APU's) for the Air Force. These units have accumulated almost 300,000 hr in service. The first engines shipped had a 500-hr overhaul schedule, but initial results were so satisfactory that the time has been increased to 750 hr.

Controls and accessories account for 75–90% of the maintenance required between overhauls. A typical problem was accumulation of metal chips in the governor, which caused valves to stick. A 5–8-micron filter ended that difficulty. On one installation, fuel leaked from the fuel pump into the gearbox and better sealing of the pump bearings was required. Pumping gasoline to the high pressures needed for proper atomization has indicated the need for special pumps. Overfilling of the gearbox has caused oil foaming, a loss of oil pressure, and an automatic shutdown. One APU was found to have hydraulic fluid in the oil sump, placed there in an earlier service period, but it ran with that as a lubricant for 120 hr.

Bearing failures invariably are traced back to improper assembly procedures. With rigid control of assembly, bearing failures are few. Foreign objects passing through the engine have always been a potential problem. To meet this, an inlet screen of ¼-in. grid spacing is provided.

To make the installation of an APU in one airplane, removal of the generator and inlet screen was required. Reassembly under poor conditions led to several cases of nuts, bolts, and lockwire dropping into the machine.

When these units are first placed in service, the crews tend to play with them. They start the units, run them up to speed, and then shut them down. Without an opportunity for batteries to recharge, the low voltage causes relays and solenoid valves to drop out, and starting with a low battery is impossible.

Use of pneumatics in the acceleration control and for other control functions has been extremely satisfactory once it was learned to keep dirt, as well as water and ice, out of them.

A precision-cast turbine rotor was used in the initial design, but metallurgical problems and difficulties in fixturing for machining and balancing led to the use of a fully machined forging. No rotor has ever ruptured in service; damage has been confined to the loss of vanes and no broken part has ever come through the turbine shroud. Units have run for considerable time with pieces missing from the turbine rotor. In severe cases, the initial warning of damage is vibration or loss of power.

The 500-hp Jupiter is an axial-flow unit with a 10-stage compressor and a 3-stage turbine. It was developed to drive a U.S. Navy emergency generator set and was the first gas turbine ever installed in a Navy ship. That was in 1951. Later, the basic powerplant was applied successfully as a boat propulsion unit and as a compressed air source for jet-engine starting.

Developed on a limited budget, the Jupiter had realtively few of the "bugs" usually associated with new designs. To minimize length it was designed with a combustor paralleling the compressor. This required a compressor

Aeroquip

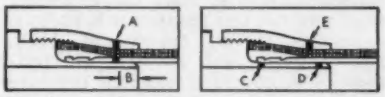
Engineering Notes



B. A. MAIN, JR.

The advertisement at your right says the "***super gem***" Fitting is leakproof, and in this column we want to show why we believe this is true.

Three holes equally spaced around the fitting were drilled at A through the socket and through the hose inner tube. This was done to by-pass the lip seal and establish that the fluid would get by the compression area at some pressure level. Subsequent proof tests, using JP-4 fuel, showed that area under compression through length B would leak at approximately 1000 psi.



Next, holes were drilled at C, D and E in other samples to by-pass the compression area and establish the effectiveness of the lip seal.

The hose lines were then aged in air at 500°F for a total of 664 hours. They were checked as follows:

At 118 hours proof tested, using JP-4 fuel at 4000 psi—OK
At 160 hours proof tested, using JP-4 fuel at 4000 psi—OK
At 328 hours proof tested, using JP-4 fuel at 4000 psi—OK
At 664 hours proof tested, using JP-4 fuel at 4000 psi—OK

These tests were conducted on the —8 size. Further tests on other sizes resulted as follows:

—4 Size 504 hours total at 500°F ageing
No leakage at 5000 psi, using JP-4 fuel
No leakage at 29" Hg
Finally burst tests—Sample 1=13,000 psi
Sample 2=12,800 psi
No leakage at fittings before burst
—6 Size 480 hours total at 500°F ageing
No leakage at 5000 psi, using fuel
No leakage at 29" Hg
Burst tests not conducted
—8 Size Aged 106 hours at +500°F, then 24 hours at —88°F, then 360 hours at +500°F.
Checked at each stage:
No leakage at 5000 psi, using fuel
No leakage at 29" Hg
Burst tests—Sample 1=9500 psi
Sample 2=9000 psi
—10 Size 408 hours total at 500°F ageing
No leakage at 4200 psi, using fuel
—8 Size 816 hours total at 500°F ageing
No leakage at 4000 psi, using fuel
—6 Size 672 hours total at 500°F ageing
No leakage at 4000 psi, using fuel

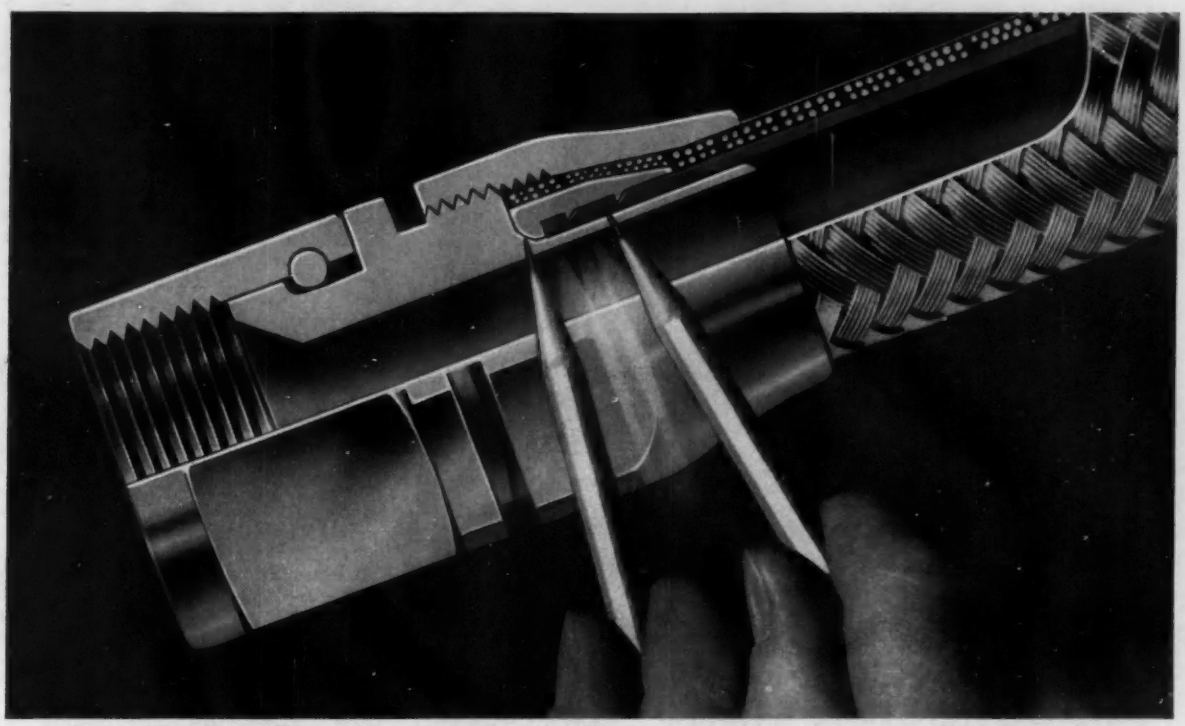
These tests demonstrate that the fitting design is sound. Beyond these tests the conventional tests such as the impulse test, fuel circulation tests and lubricating oil tests have been conducted on all the sizes —3 through —16 successfully, again substantiating the fitting.

Not completed yet is a continuous flexing and constant pressure test that has now been running somewhat over 4000 hours at about +400°F. This test covers four sizes from —4 through —12. We want to complete 6000 hours, after which higher pressure leakage tests and finally burst tests will be run. During the 4000 hours already accumulated there has been no leakage at the fittings.

In all of the tests, the "***super gem***" Fitting has not leaked. Compression fittings, both detachable and swaged, tested comparatively in these tests did leak.

B. A. Main Jr.

VICE PRESIDENT, ENGINEERING
AEROQUIP CORPORATION



Cutaway of "*super gem*" Fitting with line seal pointed out at left and lip seal at right. Together they furnish permanent protection against leakage.

The Only Leakproof Teflon* Hose Line!

BECAUSE OF AEROQUIP "*super gem*" FITTINGS

The method of fitting attachment provides the key to successful performance of Aeroquip Teflon Hose Lines in prolonged operation. Aeroquip's unique, patented "*super gem*" Fittings offer double protection against leakage:

1—a positive metal-to-metal line seal against all pressures.

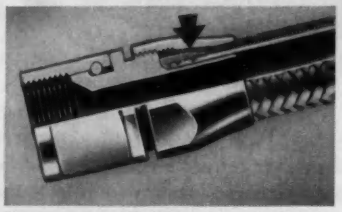
2—a lip seal formed by the Teflon tube seated, but not compressed, in a special chamber within the fitting.

This means that the *hose assembly* life under pressure is as long as the life of the Teflon hose itself—a statement that cannot be made of assemblies using compression type fittings because of the cold flow characteristics of Teflon.

Because "*super gem*" Fittings are reusable and can be readily assembled with hand tools, Aeroquip Teflon Hose Lines offer many design and installation advantages. Fill in and mail the attached coupon for a copy of Aircraft Engineering Bulletin AEB-13.



Mock-ups and modifications are quick and easy because Aeroquip 666 Teflon Hose and Reusable "*super gem*" Fittings can be assembled and disassembled by hand.



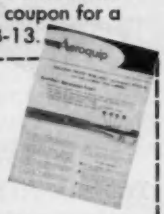
"*super gem*" Fittings grip only the wire cover on 666 Teflon Hose. This avoids possibility of cold flow or compression set which can decrease the effective life of the hose line.

"*super gem*" is an Aeroquip Trademark. *DuPont trade name for its Tetrafluoroethylene resin.

Aeroquip Corporation,
Jackson, Michigan

Gentlemen:

Please send me your Bulletin AEB-13 on reusable "*super gem*" Fittings and 666 Teflon Hose.



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PHOENIX WYTEFACE (non-metallic) Woven Tapes made from extra strong synthetic yarns, are harder wearing, with higher tensile strength and dimensional stability than ordinary woven tapes. A special plastic coating on both sides protects the line against hard use, water, stones or brush.

The end of the line is enormously strengthened by a lamination of Flexi-Foam, a spongy plastic-rubber. No stitches or hinge point to weaken the line.

A Highway Engineer reported of the non-metallic PHOENIX WYTEFACE, "It has at least three times the life of an ordinary metallic tape." *Ask Your K & E Dealer!*

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air inlet in the middle of the engine rather than in front, and such major problems as have been met arose from this arrangement. With a single combustor, compressor discharge and turbine inlet scrolls were required, and the assymetrical design, together with the high pressure and temperature in these scrolls, created problems of distortion.

The U.S. Navy recently ran 1500-hr endurance runs on two Jupiter engines. During the runs, an air seal on a cooling line failed frequently. Removal of the seal and a modification to the cooling system eliminated the problem. Items requiring replacement were combustor liners and igniter plugs. Malfunctions were almost all due to controls and instrumentation.

The only other major design problem met occurred on the latest production version, the T-300J air bleed unit. Qualification testing required hot shutdown and immediate start up shortly thereafter. This brought to light a problem of heat soak through the turbine disc and shaft to the roller bearing adjacent to the turbine. Maximum temperatures on the bearing adjacent to the disc were found to exceed the desired limits, causing metallurgical changes in the bearing and loss of internal clearance due to thermal expansion. A start with the bearing hot would result in a failure of the roller bearing. A study of the heat flow in the turbine shaft enabled a redesign of the shaft to eliminate this problem.

Development headaches were, as usual, caused largely by the controls, involving governors, acceleration limiters and the associated electrical equipment.

Operation where exhaust fumes or oil vapors could enter the compressor inlet has resulted in fouling the compressor, with marked reduction in performance. Cleaning with Carboblast has proved effective in restoring performance.

(Paper, "The Small Gas Turbine: Problem and Promise," on which this abridgment is based is available in full, in multilith form from SAE Special Publications, 485 Lexington Avenue, New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Fuel Economy Is No Accident

Based on paper by

LES VILAND

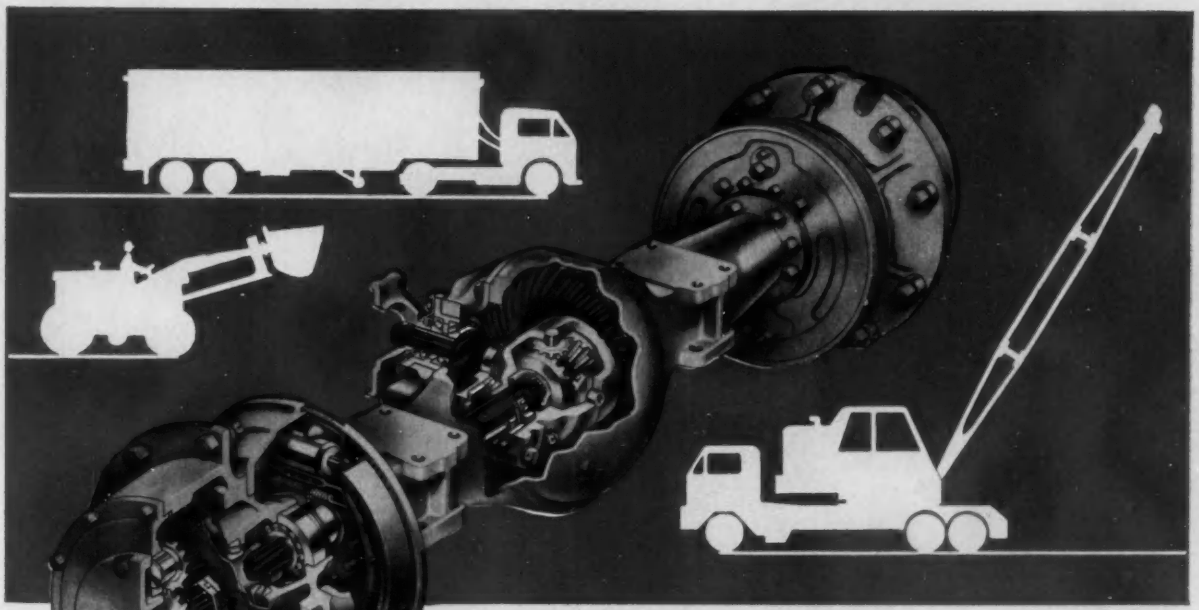
and

CARL CHAKMAKIAN

American Motors Corp.

THE Rambler attains its low fuel consumption (32 mpg in a recent cross-country run) because its engine is designed with fuel consumption very much in mind.

An OHV engine is basically more

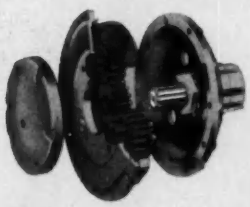


How to control that costly broken-shaft nuisance . . .

CLARK Planetary AXLE



Primary Reduction in the center section, by helical bevel pinion and gear.



Second Reduction in the drive wheel —a sun gear splined to the axle shaft and three planet gears driving an internal gear in the inner periphery of the wheel, as close as possible to the point where tractive effort is applied. Two types: steering and non-steering.

Check the extraordinary record of performance established by this axle —in the toughest service any axle is required to meet:

- **Excavator Cranes**
- **Tractor-Shovels, Bulldozers, other construction machines**
- **Heavy Duty Trucks for highway and off-highway operations**
- **Tandem-Drive Units for all applications**

Here's a simple engineering idea that hit the jack-pot in spectacular fashion—the Clark Planetary Drive Axle. File these startling facts in your mind:

Reduced torque load on shafts—Putting the planetary assembly (the final reduction) in the drive-wheel hub, takes 70 per cent of the torque load *off the axle shafts.* Result: shaft wind-up and surge virtually eliminated—and *broken axle shafts practically unknown!*

Less weight—yet stronger—an astonishing fact: severest torque loads, typical of extreme off-highway service are handled easily by gears and shafts smaller in size and therefore considerably lighter in weight than conventionally designed axles of equal capacity.

Road speeds up to 30 mph—an outstanding combination of rugged power characteristics plus highway speeds up to 30 mph for job-to-job travel —a big and vital saving.

Special for truck operators—faced with extremely difficult hauling conditions, truck owners have converted regular units to 4-wheel drive by installing two Clark Planetary axles (with Clark Torque Converter and Clark Transmission)—*with complete success.*

Don't fail to get the facts about this revolutionary solution to numerous problems. The coupon will get those facts to you—immediately.

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BLEND WITH ENJAY PARANOX®

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Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Write, wire or phone the Enjay Company today.

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economical than an L-head. The combustion chamber is more compact and loses less heat to the water jacket. The OHV design permits more efficient breathing; it gives more room in the engine compartment, thus promoting better cooling. It lends itself better to the small displacement than the V-8 engine.

In carburetion, the best-power mixture is quite different from the best-economy mixture. For maximum economy and maximum power, a carburetor must be worked out to operate smoothly under all loads. Common practice is to release a richer than required carburetor to cover variations in engine and carburetor. A production carburetor closer to optimum can be specified by paying diligent attention to calibrating it to fit engine requirements.

Among other things which help economy are: intake manifold cast in cylinder head, combustion-chamber design to permit higher compression without the use of premium fuels, low frontal area to reduce wind resistance, and a very favorable ratio of horsepower to weight.

(Paper, "Fuel Economy Need Not Be Forgotten," was presented at SAE Northern California Section. Is is available from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Tractor Equippers Want Design Changes

Based on paper by

A. W. ACKER
Henry Mfg. Co., Inc.

SMALL farm tractors, equipped with front end loaders, backhoes, or combinations of both, are doing the work formerly done by equipment ranging in size from the small hand shovel to large excavating machines.

The small hydraulically operated backhoe, in particular, has become a highly competitive item, but its mounting presents difficult problems because no provisions have been made for it by the tractor manufacturer and no two tractor models are alike.

Here are some of the installation problems faced by the equipment producer:

Several sizes of loader frames are required because of the variation in length and front axle position found on similar tractor models.

It is almost impossible to design equipment so that it will not interfere with the accessibility of battery and oil bath air cleaner which must be serviced frequently.

There is a lack of mounting surfaces and bolt holes for mounting heavy equipment. They are needed near the front axle for both loaders and backhoes. The rear axle should have square flat surfaces or adequate machined and drill mounting points near the inside face of the front wheels. Several tractors do have mounting holes but they are placed in inaccessible locations or where attachment would interfere with steering.

Hydraulic pumps larger than those furnished with the tractor are often needed. Could we not have standardized front mounted pto and pump mount that would suit mounted implements?

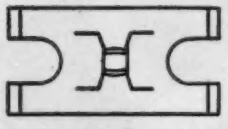
Design changes which would affect performance are:

A heavy duty, non-adjustable front axle with 6:00 × 16 in.—6 ply or larger tires is needed. Existing axles sometimes fail under work with front end loaders.

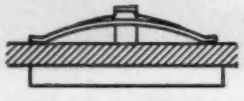
Steering gears with fast gear ratios are hard to turn with heavy loads. They are also subject to steering wheel whip when traveling over rough ground. Power steering should be available for

THIS Fastener works every time!

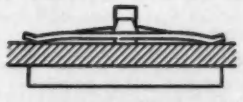




Four Gripping Teeth provide maximum gripping action, even on hard chrome studs.



Long, High Spring Arch maintains tension in service; compensates for wear on parts.



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The improved design of Type "H" PUSHNUTS brings you ease and speed of application—savings on assembly costs—security of fastening never before achieved on unthreaded studs. With all their advantages, PUSHNUTS are very low in price. Made of tempered spring steel in plain, parkerized and cadmium finishes. Sizes for 1/16", 3/32" and 1/8" studs. Have our fastening engineer demonstrate—or run your own tests.

Fast, Positive Assembly



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small tractors.

Transmissions should permit shifting from first or second gear to reverse in one short straight motion.

Smoother operation could be had with better throttle control. A foot throttle is needed because the operator's hands are busy with other controls.

Tractor seats should provide for vertical adjustment. The present low seating makes for exhaustion when handling a hard working clutch.

(Paper, "An Industrial Job for the Agricultural Tractor," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

New Rating Needed For Generator Capacity

Based on paper by

P. W. HOUSE

Delco-Remy Division, General Motors Corp.

WHILE capacity in low-speed city driving has been a recognized factor in generator design, there has been little or no attempt to determine a numerical rating which takes all related characteristics into consideration.

City load carrying capacity is the maximum load the generator will carry in normal city driving without battery discharge. If the car's electrical load is less than this value, there will be a net charge to the battery, while an electrical load in excess of the city load carrying capacity will result in a net loss in battery charge.

The city load carrying capacity is affected by:

1. Engine speeds and proportion of time at various speeds.

2. Engine to generator drive ratio.

3. Generator performance at speeds encountered.

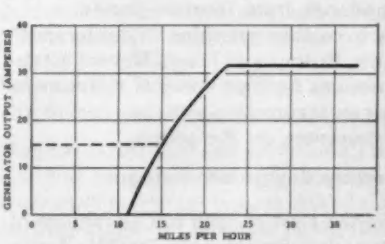


Fig. 1—Generator output versus mph for typical 35-amp passenger-car generator indicates low actual load carrying capacity during much city driving.

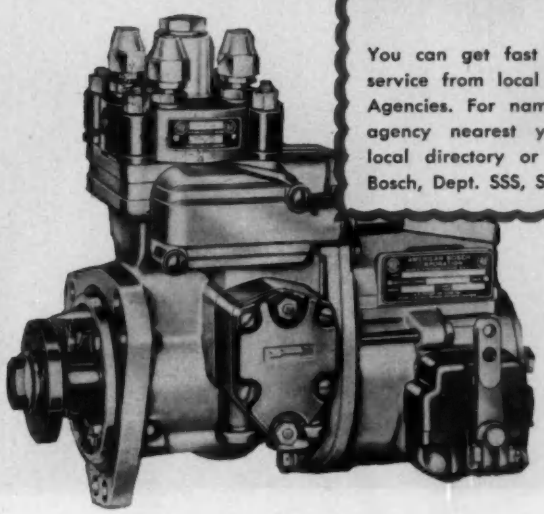
4. Characteristics of the battery and the voltage and current regulators.

5. Temperature.

A determination of the generator's actual city load carrying capacity can be made only by studying the variation in engine speeds and the percentage of time at the various speeds. Fig. 1, for example, shows the generator output versus mph of a typical 35-amp passenger-car generator. Assuming a constant speed of 15 mph, the generator would supply approximately 15 amp, or less than half its rated output. Under this driving condition the load carrying capacity would be 15 amp. Obviously, the car is not driven at a constant speed in city traffic. Sometimes the generator is at full output, while its output may be zero when the engine is idling.

(Paper, "A New Look At Generator Capabilities" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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the PSB fuel injection pump

UNEXCELLED

. . . for performance and outstanding service—that's the acknowledged record of more than 140,000 American Bosch PSB pumps now in use.

Here's some reasons why! Simple construction . . . fewer parts . . . accurate fuel metering and distribution . . . positive governor control . . . replaceable hydraulic head for fast field servicing.

What's more—all American Bosch fuel injection products are backed by a growing system of authorized service agencies, fully equipped to provide quick, efficient repair service.

Unequaled value—for top diesel engine performance and economy of operation . . . long trouble-free life . . . lower maintenance expense—nothing equals a PSB fuel injection pump.

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"Darkroom test* proves raw camera castings

High precision of Doehler-Jarvis make new cameras light-tight



Revere-made Wollensak "43"
8 M/M spool-type turret camera. Built-in filters provide finger-tip adjustment for three conditions: (1) clear shooting (2) haze (3) outdoor shots with indoor film.

Lights! Camera! Action . . .

Our hero (in darkroom above) has just snapped together the three die castings that house the new Revere-made home movie camera shown left . . . snapped them together around a tell-tale light.

The castings are raw . . . just as they come from Doehler-Jarvis. Notice no light escapes where the housing parts join. *Even before machining, the seal is light-tight.*

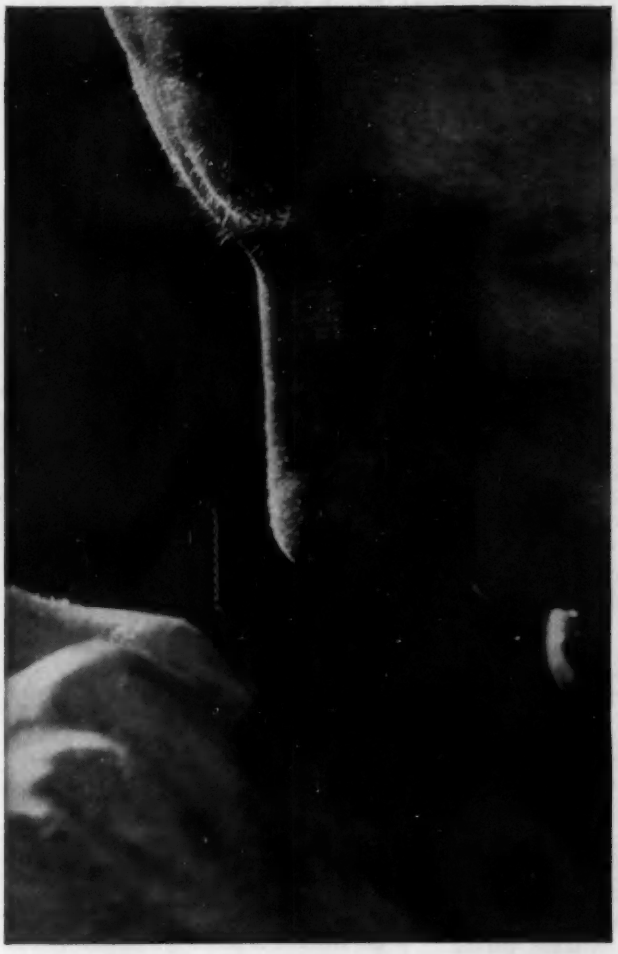
That's precision for you. The kind Revere Camera Company expects and gets from Doehler-Jarvis.

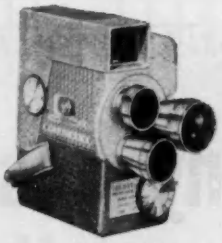
What's more, each casting provides, "no-tolerance" machining base points. From these points Revere establishes all basic dimensions for machining of the camera mechanism. They get an accuracy so high they can afford to offer a lifetime guarantee on the action.

Realizes many design advantages

Revere designs from the start to take full advantage of die casting. In most models, for example, Doehler-Jarvis is called in while units are still in the hand sketch stage.

In this instance, details worked out include the use of lightweight magnesium; ways to reduce wall thicknesses (they're way thinner than ADCI minimums); location

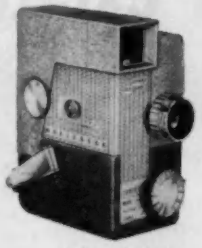




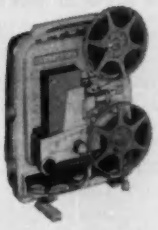
Wollensak "43"
8 MM Spool-type Turret Camera



Wollensak "815"
Automatic Slide Projector, 2x2



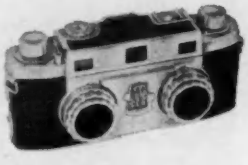
Wollensak "42"
8 MM Spool-type Cine Camera



Wollensak "715" 8 MM
Movie Push-button Projector



Wollensak "23"
8 MM Magazine Turret Camera



Wollensak "10"
Stereo Camera

*Darkroom test illustrates precision of the raw Doehler-Jarvis die castings as received for use in the above Revere-made Wollensak cameras and equipment. Revere subjects the finished cameras to a much more severe 4-hour direct sunlight test. You can be *sure* they're light-tight.

fit so closely light doesn't pass..."

die castings helps Revere even before machining

of bosses, lugs, corner reliefs; extra back-up for stressed sections; tool-ups for machining and finishing; interchangeability between this and other models. All this pushes ultimate costs down, quality up.

Net result is an outstanding camera that is proving itself on the sales counter.

Doehler-Jarvis die-casts parts for all Revere-made cameras and projectors, not only their name line, but also Wollensak and other brands. Asked why they prefer die castings made by Doehler-Jarvis, Revere put it very simply: "rejects almost zero" . . . "likewise salvage" . . . "D and J people live with our jobs".

Right now Doehler-Jarvis people are "living with" the jobs of some 1400 major users of die castings. They'll do the same for you.

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DIVISION OF NATIONAL LEAD COMPANY
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In Canada:
Barber Die Casting Co. Limited
Hamilton, Ontario

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Environmental vibration testing to MIL-E-5272 and other government specifications. This is most important now for assuring reliability of performance in military production. But the same techniques can be used also to improve *all* types of products.

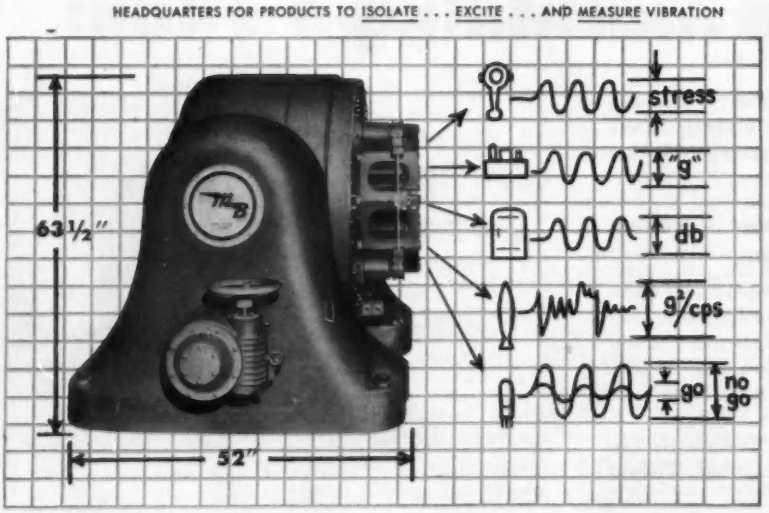
Noise. Just where in a product does it come from and how to eliminate it? An MB shaker helps pinpoint the disturbance by letting you vibrate the product through a whole range of frequencies with the twist of a dial.

Complex wave testing, including random motions. This is something *new!* It subjects a specimen to the same kind of vibration as that encountered in actual service. MB electrodynamic shaker systems offer the frequency range, high acceleration, and freedom from distortion needed for this kind of job.

Production and Quality Control. *Your* ideas are needed here. For example: Someone discovered that size of fine powder particles which sift readily through a screen varies with the screen's frequency of vibration. Permitting easy control of frequency, an MB shaker is capable of working on a *production* line! Tubes too are being production-tested with MB Exciters.

If you need help in putting vibration exciters to work, get in touch with MB . . . leading producer of vibration test equipment.

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1067 State Street, New Haven 11, Conn.
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION



Study Throws Light On Bearing Failures

Based on paper by

G. F. BONNER
Ford Motor Co.

THERE is a definite relationship between vibration, surface finish, and fatigue life of roller contact bearings. This is the finding of a study covering many phases of automotive bearing design.

The bearings investigated were representative of those commercially available to the industry in respect to surface finish, as measured by a profilometer, and surface deformation, as measured by a "micro contour" recorder. Of the two surface conditions, deformation seems to be the more important influence on bearing vibration. This vibration, especially the initial vibration, has proved to be an index of fatigue life in all tests conducted on roller contact bearings.

Since vibration is a function of surface contour, it is believed the automotive bearing designer of the future will become more conscious of ovality and the number and type of asperities met in the direction of rolling. He will also look to the metallurgist because initial vibration is an index of merit only if bearing materials and heat treatment are adequate. He will make sure that a minimum of inclusions exist in the bearing steel and that proper machining techniques are used so that premature failure will decrease.

(Paper, "A Laboratory Study of Automotive Bearings," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Getting the Best Out of Textile Fibers

Based on paper by

T. J. WALLAG
Ford Motor Co.

EACH of the fibers—natural, man-made, and synthetic—widely used in automobiles has its own special qualities to recommend it. But full advantage of these qualities depends a great deal on knowing how to use the fibers.

Specific suggestions for obtaining the maximum advantages include:

• Use rayon in the warp and nylon in the filling of rayon-nylon upholstery fabrics, instead of the other way



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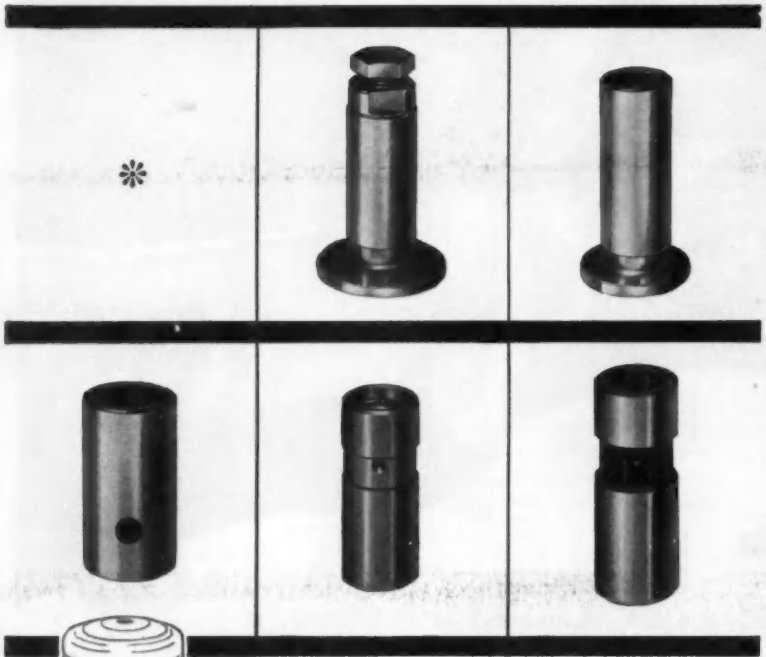
around, as is usually done. Only in this way is full advantage taken of the physical properties of the fibers.

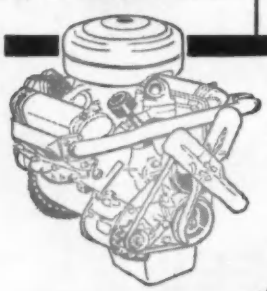
• Wrinkles on the seat cannot be corrected or eliminated in materials with very little stretch. Therefore, avoid poplin-like constructions whenever possible so as not to use the less elastic cotton or rayon fillings with rod-like characteristics. If style selection can't be changed, then adopt more elastic fibers such as nylon, saran, wool, or selected mixtures of these and other fibers.

• Charges of static electricity, characteristic of synthetic fibers and particularly noticeable with all saran fabrics, can be minimized by weaving in metallic yarns at frequent intervals and proper grounding in the seat assembly. The method is quite expensive, however.

(Paper, "Engineering With Synthetic Fibres" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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Farm Market Demands Diverse Tractor Types

Based on paper by

W. R. DALENBERG

International Harvester Co.

NO one type of tractor will dominate the farm market to the exclusion of any other. Tricycle, crawler, standard wheel, and utility types all have their advantages for particular applications in today's increasingly specialized, more highly mechanized farm operation.

It was the 4-wheel tractor that started the mechanization of farm work. About 1923, the tricycle-type appeared, making possible row-crop production without animals and leading to completely tractor-equipped farms. Then, some 16 years ago, the basic 4-wheel model was brought to the fore again, through the application of modern metallurgy, hydraulics, and manufacturing techniques, to make a truly utility vehicle.

Today, companies making a full line, produce many sizes and models, of tractors powered by gasoline, diesel, or LPG engines. To these are added optional equipment such as fast-hitch, torque-amplifier drive, transmission-driven or completely independent power take-off, power steering, power-adjusting rear wheels, and three types of front wheel equipment.

All of the various sizes and types of tractors are needed for efficient farming because of the wide range of crops, soils, climate, and cultural practices, and despite the increase in farm size and trend toward specialization.

(Paper, "The Utility Tractor's Place on the Modern Farm," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Tractor Re-Design Needed for Loaders

Based on paper by

C. W. MURRAY

and

W. J. SCHLAPMAN

Wagner Iron Wks.

MATERIALS handling equipment, particularly industrial loaders, is being used in ever-increasing number on wheeled tractors not specifically designed for such mounting. If certain


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P.S. AC's Permanent Expanding Electronic Program provides openings for more Mechanical, Electrical Engineers and Engineering Technicians. Even "square pegs" are provided "square holes" at AC.

Write today in strictest confidence to my friend, Cecil E. Sundeen, Supervisor of Technical Employment

*AC THE ELECTRONICS DIVISION

GENERAL MOTORS CORPORATION

Milwaukee 2, Wisconsin • Flint 2, Michigan

changes were made in tractor design, the usefulness of the tractor-loader combination would be greatly enhanced.

The utility tractor for loader application should be a mobile power unit and to this end the following is suggested:

- The three-point hitch with tractor hydraulics and constant running p.t.o. should be offered as optional accessory packages. In some installations they are used to operate rear-mounted equipment which is compatible with the front-end loader.

- Maximum floatation tires are required on both front and rear wheels. The front wheels must carry the heavier loads and the larger tires provide better steering during the loaded cycle. Rear wheel traction is vitally important for loader movement.

- Standard front axles (non-adjustable) reduce both cost and maintenance.

- Integrated power steering with its own independent hydraulics is an essential accessory for loader operation. This feature has contributed more to improve loader cycle time in operation than any recently introduced accessory.

- An over-riding foot throttle would contribute to faster loader cycles because it would free the operator's hands for steering, shifting, and loader control and would improve correlation between acceleration and braking.

- A direct, forward-reverse transmission gearshift pattern, or direct, forward-reverse shifter supplementing a standard transmission would also better performance of the tractor-loader combination.

- In conjunction with the previous suggestion, a high-low range transmission shifter or auxiliary transmission is of measurable benefit in loader use.

(Paper, "Industrial Loader Design Related to Utility Type Tractors," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

How to Make Tractor Suitable for Backhoe

Based on paper by

B. F. CHAPMAN
Pippin Construction Equipment, Inc.

THE expanding use of backhoes on agricultural tractors and the customer's demand for more power and speed has created severe engineering problems. Such tractors were intended to pull a load, not to carry it, and the resultant overloading has caused tractor breakage. Therefore, certain design changes are needed.

The first requirement is to strengthen the tractor's main castings—differential, final drive and rear axle housings, transmission cases, and front axle supports—so that expensive subframes can be eliminated.

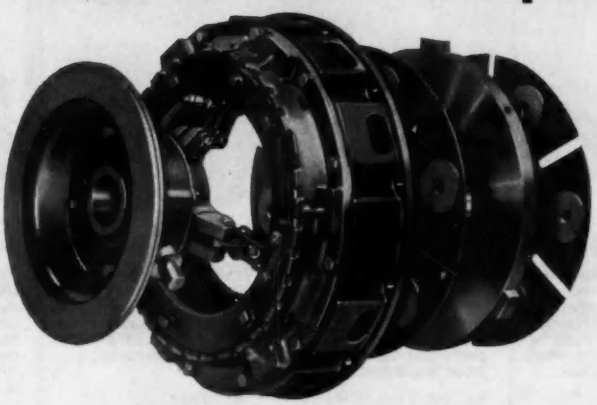
Wider rear wheel treads are also needed to give greater stability. The demand for more swing and digging arc makes this imperative for operator safety.

If a tractor can be made to support a backhoe without separate subframe, standardization of mounting points would be helpful. Complete standardization is probably impossible, but some similarity in type and location of mounting points would benefit everybody.

The hydraulic system should have sufficient capacity to handle the larger equipment. The power take-off has proved too slow for a pump drive and

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Double Plate Clutch Provides More Torque



- With Less Size

Used in a large crawler-type tractor, this Double-Plate ROCKFORD Morlife CLUTCH (Utilizing two MORLIFE® plates—equipped with button type facings) provides 100% more torque capacity than previous clutches of same diameter. 400% more service life and 50% more heat resistance are other features of this Heavy-Duty ROCKFORD Morlife CLUTCH. A brake plate is mounted on the heavy-duty, ball bearing type release sleeve.

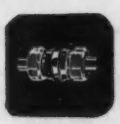
If you have a heavy-duty vehicle in the planning stage, it will pay you to learn about these and other advantages of this new clutch—before you design the drive line. A design study of your present drive lines might indicate advantages of using this ROCKFORD CLUTCH. For information write Dept. D — or

BW SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

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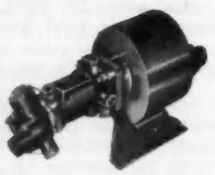
Vickers Thermal Operated Relief Valves protect the primary and secondary hydraulic systems from overheating by automatically depressurizing the circuit at a preset temperature.



Vickers 3000 psi Variable Displacement Piston Type Pumps supply power to the primary and secondary hydraulic systems on the Convair F-102A Interceptor.



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The Convair F-102A all-weather supersonic stratospheric interceptor depends on Vickers Hydraulics for the following important functions:

- Primary and secondary hydraulic systems
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The components shown here were selected by Convair for their outstanding dependability and the additional advantages they offer in superior performance. Their technological advancement keeps pace with aircraft development. The pumps are characterized by minimum heat rejection and highest overall efficiency . . . all units shown have small size and light weight. For further information, ask nearest office listed below for Bulletins A-5200-D and A-5209.

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TELEGRAMS: Vickers WUX Detroit • TELETYPE: "ROY" 1149 • CABLE: Videt
OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

this has forced going to a front end pump. The disadvantages are obvious: misalignment, interference with front equipment, long hose line resulting in friction and cavitation in cold weather, and danger to exposed pump and hoses.

If an inbuilt hydraulic system proves impractical, then the equipment producer will have to supply a pump and there must be an adequate mounting point on the tractor. This pump should be driven at engine speed, independent of the main clutch, with provision for disengaging for road travel or when not in use. Consideration should be given to convenience of location, accuracy of alignment, standard pump mountings, and clearance for drive shafts and standard couplings.

(Paper, "The Agricultural Tractor and the Backhoe," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Valve Seat Angle Item in Diesel Advance

Based on paper by

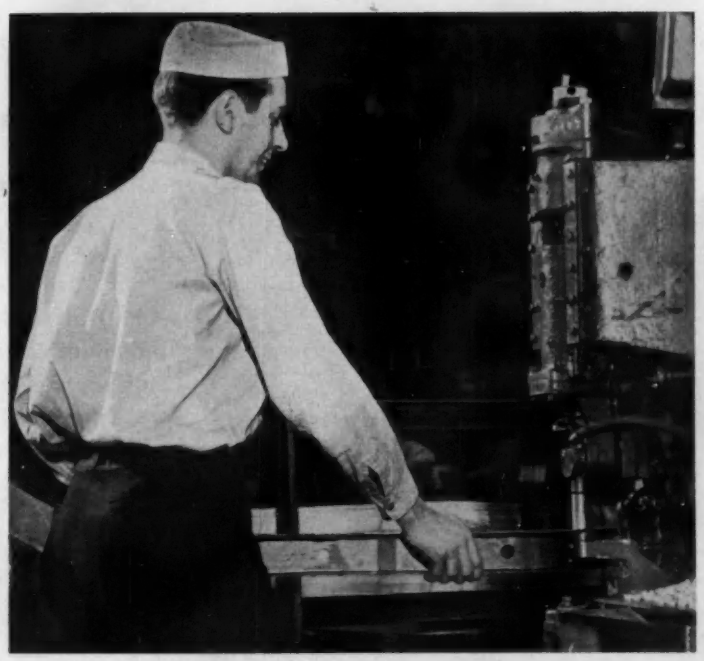
CARL VOORHIES
NORMAN FELBINGER
and
G. R. BOUWKAMP
Chicago Screw Co., Division of Standard Screw Co.

WITH the development of the diesel engine in the direction of higher speeds and loads, there needs to be a reconsideration of the valve seat angle.

This angle determines the way in which the gas load, acting on the head of the valve, will be transferred to the valve seat insert. For a given width of valve seat, this angle determines the width of the projected area in a plane perpendicular to the axis of the valve and the width of the projected area on a cylinder having a diameter equal to the mean diameter of the valve seat. Through the use of these projected areas, the pressure on the valve seat and the load tending to expand the insert can be determined.

By way of example, assuming a peak cylinder pressure of 1000 psi and a 4-in. diameter valve, the load acting on the valve head becomes 12,566 lb. With a 0.100-in. wide × 45-deg seat, the axial pressure on the valve seat becomes 14,397 lb. The valve seat insert is also subjected to a radial pressure which will produce a tensile load of 2000 lb, with the stress in the insert depending upon the cross-sectional area. Under the same conditions with a 0.100-in. wide × 30-deg seat, the axial pressure

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If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

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ACP Granodine provides an excellent base for sparkling, durable paint finishes on automotive equipment, home appliances and industrial products by chemically converting steel surfaces to a nonmetallic phosphate coating. It not only greatly increases the adhesion of the finish, but also provides extremely good corrosion resistance even when used in conjunction with a relatively thin and flexible paint film. Granodine coatings are easily and economically applied to steel surfaces by dipping, spraying or brushing.

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IN INDUSTRY, drums, materials handling equipment, machine tools and many other steel products used throughout the plant are protected by a Granodine base.

LEARN ALL ABOUT ACP GRANODINE. Bulletin 1380 describes the various types of ACP Granodine and gives information which will help you select the proper type for your particular application. Write for your copy today.



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on the valve seat becomes 11,800 psi and the radial pressure on the insert will produce a tensile load of 1154 lb. This amounts to a reduction in radial load proportional to tan 30 deg/ tan 45 deg or 0.577/1 which may be helpful in preventing valve seat inserts from loosening and in reducing wear between the valve and the valve seat.

(Paper, "Trends in Valve Gear Design," on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Automation Can Help Small-Lot Production

Based on paper by

J. R. COUGHLIN

De Soto Division, Chrysler Corp.

YOU don't have to be a big volume producer to enjoy the benefits of automation. There are, however, two requisites to be met to make automation practical.

First, there should be as much standardization as possible so that similar but not identical parts can be produced on the same automated equipment. This can bring volume up to the point where mechanization is warranted.

The second essential is that automation equipment and techniques developed by other industries be employed and adapted to the particular needs. In this way the tremendous cost of development can be avoided.

In the farm tractor and implement industry automation has been put to good use. For example, valve springs can now be processed through a fully automatic electronic inspection and segregating machine.

This machine automatically loads, compresses to solid height, measures length, measures compressive load, segregates, accepts and rejects, according to measured length and load, and paints an identification stripe. This is a fully automated, quality-controlled operation which has increased production and decreased cost.

Another example from the farm tractor industry is found in foundry practice. A fully automatic diaphragm molding unit compresses the sand with 350-psi pressure, using a rubber diaphragm. It permits casting size and finish to be controlled more accurately, molding time per unit to be reduced substantially, while the operation is made safer and less fatiguing to the operator.

Many implement parts are being produced with a 10-station automatic submerged arc-welding machine. The parts are loaded into a fixture and are automatically indexed beneath the welding arc.

Automation of this type may be termed limited. You do not push a





Are your Oil Seals burning up?

Oil seal failure often results from excessive heat . . . caused by friction plus high operating temperatures. New hi-temperature applications for both lubricating and Type-A transmission oils are putting the heat on seal manufacturers.

That's why IPC has custom compounded new BUNA-N seal materials especially for hi-temperature use. In many instances, IPC's BUNA-N Oil Seals are ideal for operating temperatures up to 325° F.

Naturally your specific application is the deciding factor. If you're interested in lower-cost oil seals for temperatures up to 325° F. be sure to check your specifications with IPC . . . the foremost custom compounders of packings — oil seals — precision molding.

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INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

PACKINGS · OIL SEALS · PRECISION MOLDING

P2

button and get a finished part. Each machine works with the part in one position, lateral displacement being the only change in position, and hand turnovers being required between machines. With greater volume, these machines could be hooked together with turnovers, to bring fuller automation.

(This article was based on the secretary's report of the panel on Automation. Panel leader was W. B. Shimer, De Soto Division, Chrysler Corp.; secretary was J. R. Coughlin, De Soto Division, Chrysler Corp. Panel members were: G. C. Joynt, Tractor & Implement Division, Ford Motor Co.; R. M. Olsen, Massey-Harris-Ferguson, Inc.; G. M. Olson, Ingersoll Milling Machine Co.; T. E. Seavey, Pontiac Motor Division, General Motors Corp.; B. D. Smith, International Harvester Co.; Gordon Swardenski, Caterpillar Tractor Co. This report together with 7 other panel reports is available as SP-316 from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members; $3.00 to nonmembers.)

Shift to 12-V Systems Spurs Better Batteries

Based on paper by

H. D. WILSON
Ford Motor Co.

THE trend from 6- to 12-v electrical systems has had a tremendous impact on the battery industry. It has brought 15 new SAE battery group sizes with capacity ratings ranging from 45 to 70 amp-hr increments, with four different terminal arrangements.

Styling, increase in engine sizes, and underhood installation of power brake, air conditioning, and other control equipment has made it necessary for body engineers to specify batteries of varied configurations and terminal locations. So, instead of six batteries or less, which might have been made to cover requirements, there are now 15, with probably more to come.

This is understandable from the automotive engineer's viewpoint, but it has placed a heavy burden on the battery manufacturer and will hit all merchandisers of replacement batteries, who must now stock the new 12-v sizes in addition to the great number of 6-v sizes.

The multiplicity of types, many of them slow-moving, has stressed the need for battery construction permitting long periods of storage without deterioration. The "dry-charged" battery fills this need. It has been available to the military for many years, but was considered too costly for general use.

There are those who believe that the loss of charge in wet-charged batteries can be reduced to a point where there would be less need for the more expensive dry-charged type. Leading in this direction has been the development of corrosion-resistant alloys in the positive plate grids.

Use of these alloys has reduced self-discharge and capacity loss on standing on open circuit, resulting in less sulfation and better shelf-life. These alloys permit a reduction in the number and cross-section of grid wires, which means a substantial reduction in grid weight and cost, and a small increase in volume of plate active material.

(Paper, "Developments In Storage Batteries" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

DETROIT *Vernatherm*® THERMOSTATS
GIVE YOU DEPENDABLE
COOLANT CONTROL!



Vernatherm thermostats by Detroit Controls have a reputation for solving knotty problems in the roughest kinds of service. Big engines doing big jobs rely on Vernatherm thermostats. Cooling system difficulties in millions of passenger cars have been eliminated. Why not investigate Vernatherm thermostats for your engines?

Pioneered by Detroit Controls to meet the needs of modern pressurized cooling systems, these superior thermostats are solid-charged for power and accuracy, specially engineered for each job.

Call on DETROIT sales engineers for test data and actual results in the field . . . or write for Bulletin 213.

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Division of AMERICAN RADIATOR & STANDARD SANITARY Corporation

Representatives in Principal Cities
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AUTOMATIC CONTROLS FOR TRANSPORTATION • AVIATION • AIR CONDITIONING
REFRIGERATION • DOMESTIC HEATING • HOME APPLIANCES • INDUSTRIAL USES

New Members Qualified

These applicants qualified for admission to the Society between Feb. 10, 1957 and March 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Baltimore Section

Wesley M. Jester (A), Lemuel O. Warfield (J).

British Columbia Section

Godfrey J. H. Dean (M), Edward Kaila (J).

Buffalo Section

Charles F. Desmond (M), Warren D. Hils (J).

Canadian Section

Robert M. Buchanan (A), William J. Budd (J), John M. Delorme (A), Ronald E. Lister (J), John D. Nasmith (A), John A. Reynolds (M), John M. Templeton (A).

Central Illinois Section

George W. Carson (J), Norman E. Goelzer (J), Dean E. Hilst (J), William H. Hoerr (J), Allan G. Marr (J), W. Miller Owen (M), Clayton C. Smith (A).

Chicago Section

W. H. Bechman (M), Robert S. Bloomfield (A), William F. Dawson (J), Frank C. Edwards (M), Harold W. Grube (M), Eugene M. Hoganson (M), Mack M. Jones (M), Ray Edward Koskie (J), Walter A. Parrish, Jr. (M), George D. Shutak (A), Lloyd F. Wenker (A), Harry R. Wierzbicki (A).

Cincinnati Section

Peter R. Tolley (M), Chalres Byrchard West (M), R. C. Westerfield (A).

Cleveland Section

William C. Blunt (A), Donald A. Gustafson (J), Anthony John Lalli (M), Forrest L. McCracken (M).

Dayton Section

William R. Alexander (M), Edward P. Harris (M), Fred L. Sumser (M), Joseph J. Thoma (M).

Detroit Section

Eugene J. Barney (M), James B. Bibb, Jr. (J), David J. Burkhardt (J), James W. Carl, Jr. (M), Frank Carollo (J), James F. Clark (A), Stephen M. Daniska (A), Raymond H. Defauw (M), Robert M. Dwyer (J), John Einar Filippi (J), James H. Frye (J), Theodore W. Gasparski (M), J. L. Gilliam (A), Robert A. Hanson (J), George C. Harbert (M), John A. Holm (M), Edwin W. Hurd (M), Eugene P. Jacoby (J), H. Dean Jensen (J), Richard I. Jones (A), John T. Kosinski (J), John L. Lehmann (J), E. H. Lejuste (A), John E. Mahoney (J), Anthony W. Markhauser (A), Herman J. Mestl (M), Robert C. Montgomery (J), Warren L. Moody (J), Fred L. Siebert, III (J), Robert C. Sneckenberger (J), James P. Tomlinson (A), Herbert C. von Rusten (J), Stuart P. Weckerly (M), Thomas H. Williams (J), Alfred C. Wooll (M), M. E. Zellen (A).

Indiana Section

Richard R. Booth (J), Warren H. Chase (M), Allen C. Harra (M), John Edgar Irwin (M), James J. Waygood, Jr. (M).

Kansas City Seection

Robert M. Frost (M), Don Keith Hereford (J), Jack McCuaig (A).

Metropolitan Section

John F. Herr (M), Frederic A. Hicks (M), Paul George Jameson (M), Victor C. Leglise, Jr. (A), Roger Paul Lewis (J), Ray Matlock (A), Eugene H. Okrent (J), Joseph M. Rodriguez, Jr. (A), Harris J. Shapiro (M), J. P. Thorn (M), Vincent L. Vaillancourt (J), George M. C. Wolff (M), Rajih M. Yusuf (J).

Mid-Continent Section

Donald E. Lowrey (A).

Mid-Michigan Section

Kenneth F. Fowler (J), John L. Lass (J).

Milwaukee Section

Ernest E. Hesson (J), Ronald J. Klatt (J), R. T. Leuloff (A), David W. Mauger (J), Mark J. O'Connell (J), Robert C. Wegner (M).

Mohawk-Hudson Section

Edward A. Dessureau (A), Thomas Nicholson (M), Jeffrey N. Shinn (J).

Montreal Section

R. J. Boileau (M), Ian W. Shepard (M).

New England Section

Francis W. Dorion (M), Arnold J. Knox (A), Edward W. Reardon (A), F. Cort Turner (A).

Northern California Section

Edwin Charles Allen, Jr. (J), Henry F. Kipp (M), Howard Wick (M), Jack Gordon Wogoman (A).

continued on page 141

To the ENGINEER of high ability

Through the efforts of engineers The Garrett Corporation has become a leader in many outstanding aircraft component and system fields.

Among them are:

air-conditioning

pressurization

heat transfer

pneumatic valves and controls

electronic computers and controls

turbomachinery

The Garrett Corporation is also applying this engineering skill to the vitally important missile system fields, and has made important advances in prime engine development and in design of turbochargers and other industrial products.

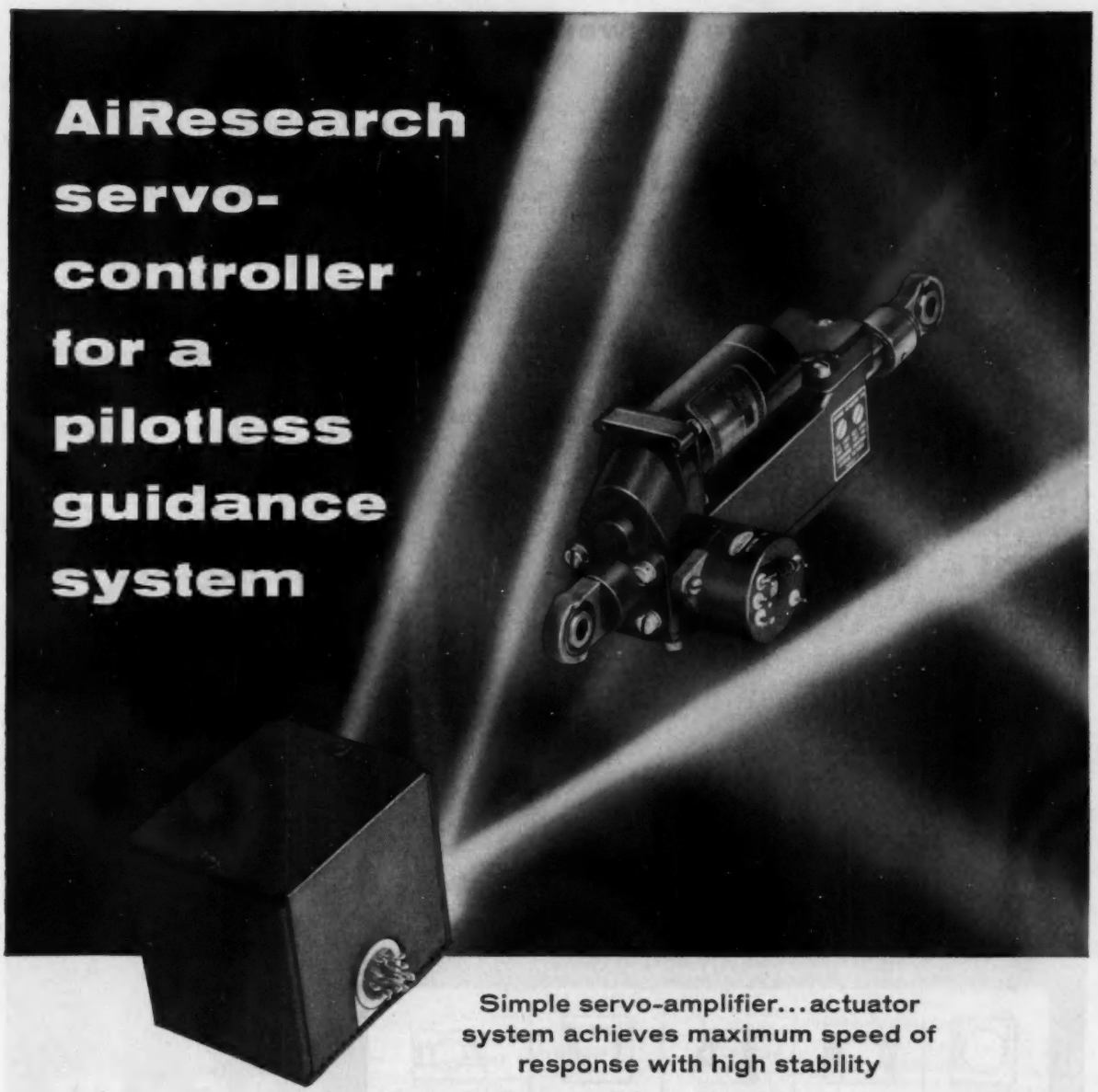
Our engineers work on the very frontiers of present day scientific knowledge. We need your creative talents and offer you the opportunity to progress by making full use of your scientific ability. Positions are now open for aerodynamicists ... mechanical engineers ... mathematicians ... specialists in engineering mechanics ... electrical engineers ... electronics engineers. For further information regarding opportunities in the Los Angeles, Phoenix and New York areas, write today, including a resumé of your education and experience. Address Mr. G. D. Bradley

THE GARRETT CORPORATION

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DIVISIONS
AiResearch Manufacturing, Los Angeles
AiResearch Manufacturing, Phoenix
AiResearch Industrial
Rex — Aero Engineering
Airsupply — Air Cruisers
AiResearch Aviation Service

AiResearch servo-controller for a pilotless guidance system



Simple servo-amplifier...actuator system achieves maximum speed of response with high stability

Because most missiles and drones are self-destructive, it is important that the components in their guidance systems be both highly accurate and dependable and be producible in quantity at low cost. The AiResearch servo-controller meets the above requirements.

It operates as follows: an AiResearch servo-amplifier weighing less than .7 of a pound amplifies electric signals from an inertial guidance source and converts them to command signals. These in turn are transmitted to an AiResearch electrically-powered light weight linear actuator which adjusts control surfaces of missile or drone to maintain a predetermined course.

The servo-controller can operate from either a DC or AC power supply. It can also be designed to take signals from celestial, telemetering or pre-programming sources to maintain or readjust the course of its pilotless air vehicle. It is another example of the AiResearch Manufacturing Division's capability in the missile field.

Inquiries are invited regarding missile components and sub-systems relating to air data, heat transfer, electro-mechanical, auxiliary power, valves, controls, and instruments.

Outstanding opportunities for qualified engineers.

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AiResearch Manufacturing Divisions

Los Angeles 45, California... Phoenix, Arizona

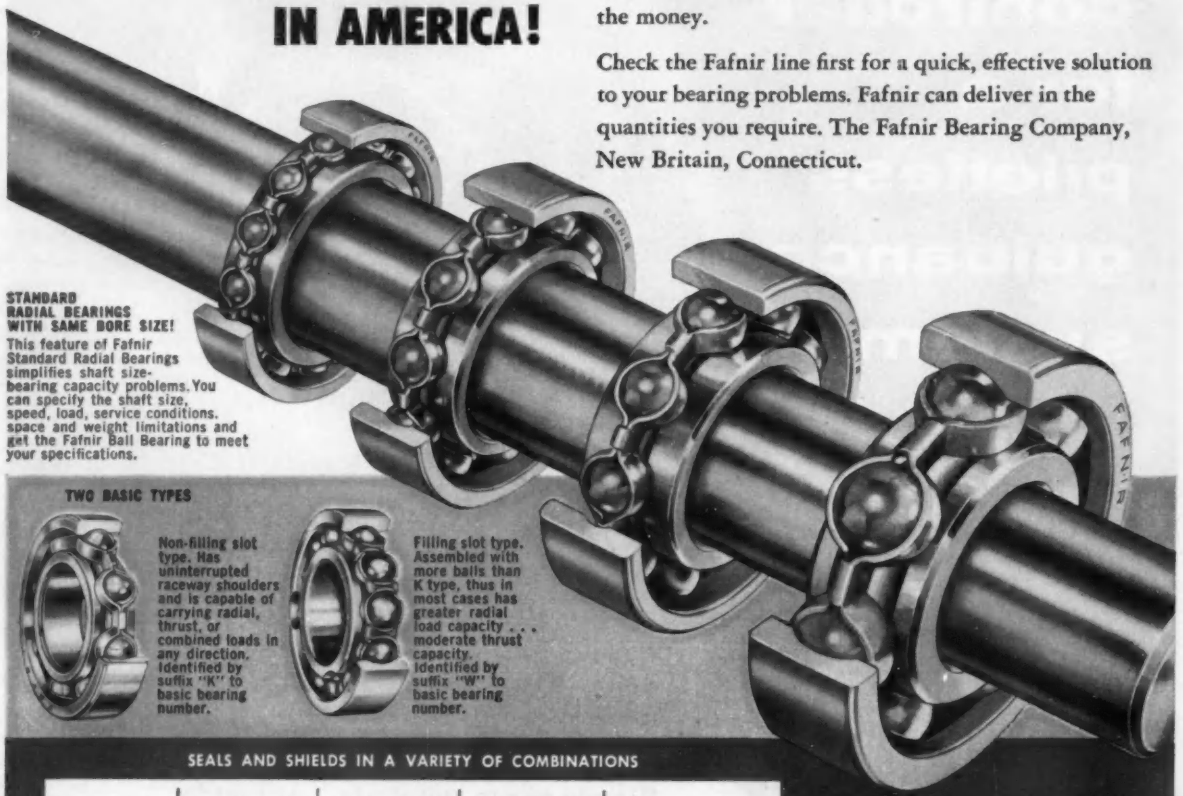
Designers and manufacturers of aircraft and missile systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS • CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

For the most effective answers to your bearing problems...

FAFNIR OFFERS THE MOST COMPLETE LINE OF BALL BEARINGS IN AMERICA!

Whatever your bearing needs, your best bet is Fafnir. The reason . . . Fafnir makes America's most complete line of ball bearings, ranging from standard radial to custom-made jet engine types. Various tolerances and combinations of seals and shields enable Fafnir to supply the best bearing for the purpose — the *most* bearing for the money.

Check the Fafnir line first for a quick, effective solution to your bearing problems. Fafnir can deliver in the quantities you require. The Fafnir Bearing Company, New Britain, Connecticut.



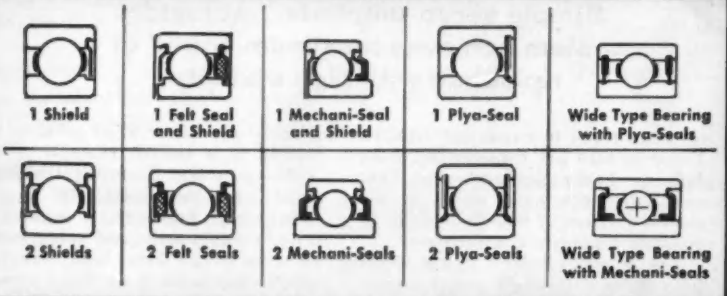
STANDARD RADIAL BEARINGS WITH SAME BORE SIZE!
This feature of Fafnir Standard Radial Bearings simplifies shaft size-bearing capacity problems. You can specify the shaft size, speed, load, service conditions, space and weight limitations and get the Fafnir Ball Bearing to meet your specifications.

TWO BASIC TYPES

Non-filling slot type. Has uninterrupted raceway shoulders and is capable of carrying radial, thrust, or combined loads in any direction. Identified by suffix "K" to basic bearing number.

Filling slot type. Assembled with more balls than K type, thus in most cases has greater radial load capacity . . . moderate thrust capacity. Identified by suffix "W" to basic bearing number.

SEALS AND SHIELDS IN A VARIETY OF COMBINATIONS

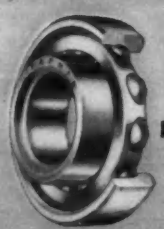


FAFNIR BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

POPULAR TYPES



Wireloc
(Snap ring type)



Front Wheel



Double Row

New Members Qualified

Continued

Northwest Section

Harold M. Olden (J), Clarence E. Street (A).

Philadelphia Section

George M. Bateman, Jr. (J), Victor E. Boccelli (A), Elliott F. Daniels (A), Russell F. Gerhart (A), John W. Hannigan (J), Joseph H. Harrison (J), Frank E. Mamrol, Jr. (M), T. J. Nicholson (A), Otto E. Parkkonen (A), John S. Richards (J), John Romanchick (A), William L. Wascher, Jr. (J).

Pittsburgh Section

Stewart G. Fletcher (M), George P. Futas (J), William S. McChesney (A).

St. Louis Section

Raymond L. McGirl (M), Carl E. Widell (M).

Salt Lake Group

John H. Coverdale (J).

San Diego Section

James M. Barrett (J), Philip W. Corbett (M), Tauge Ted Diver (A), Jack S. Foster (A), George W. Hedling (A), Orla Silas Hoffer (M), Robert H. Jenkins (M), William A. Meixner (M), Joseph R. Tueller (J).

South Texas Group

Ben Darlington White (M).

Southern California Section

Richard Baverstock (M), M. Keith Borg (J), Arthur C. Brown (M), James Parker Brown (M), Lt. James A. Deshazo (J), Sherman W. Evans (A), Paul E. Haines (A), Duane W. Hendrickson (A), Richard Bohman Holst (J), Luther U. Shaw (M), Cloyd Smith (M), Hiroshi Tayama (J), Peter Thatcher (M), Benjamin T. Wakabayashi (J).

Southern New England Section

James V. Altieri, Jr. (J), Erling J. Bligard (M), William Roger Chase (J), Leland D. Cobb, Jr. (J), John W. Kelly (M), Richard J. Nowak (J), Raymond E. Smith (M).

Spokane-Intermountain Section

Collin Slane (A).

Texas Section

E. Y. Beaver (A), Herbert G. Bradford (M).

Twin City Section

G. M. Carmichael (A), James S. Holdhusen (M).

Wichita Section

Donald F. Hoadley (M).

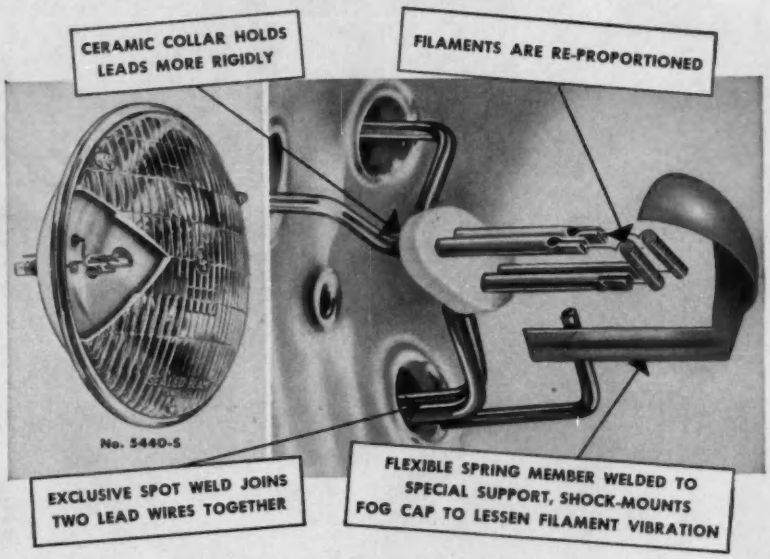
Outside Section Territory

James F. Board (J), Daniel A. Chase (A), Ronald P. Holmes (J), Lt. Dudley Mason, Jr. (A), Kenneth H. Mindrum (M), Hubert A. Payne (A), Cyril Bruce Rogers (M), Robert I. Williams (M).

Foreign

Bernardo Blaschitz (J), Venezuela; Richard Hoon (M), Holland; Toufic Rached Houry (J), Lebanon; Kondamudi Kameswara-Sarma (J), India; As'ad Fuad Khairallah (A), Lebanon; Howard John Lister (A), England.

THE MOST RUGGED TRUCK AND BUS HEADLAMP EVER BUILT!



The Tung-Sol Vision-Aid Truck Headlamp, long recognized for meeting the toughest service conditions, is now more durable than ever before. This new ruggedness is produced by spot welding two of the lead wires together (an exclusive Tung-Sol feature) and by use of a ceramic collar which stiffens the entire filament structure. Also, the filaments themselves have been re-proportioned—thus making the filaments less receptive to vibration and shock. Flexible anti-shock spring member welded to special support isolates fog cap from filament structure.

Exhaustive laboratory impact tests clearly reveal that this new lamp will stand more abuse than any previous headlamp.

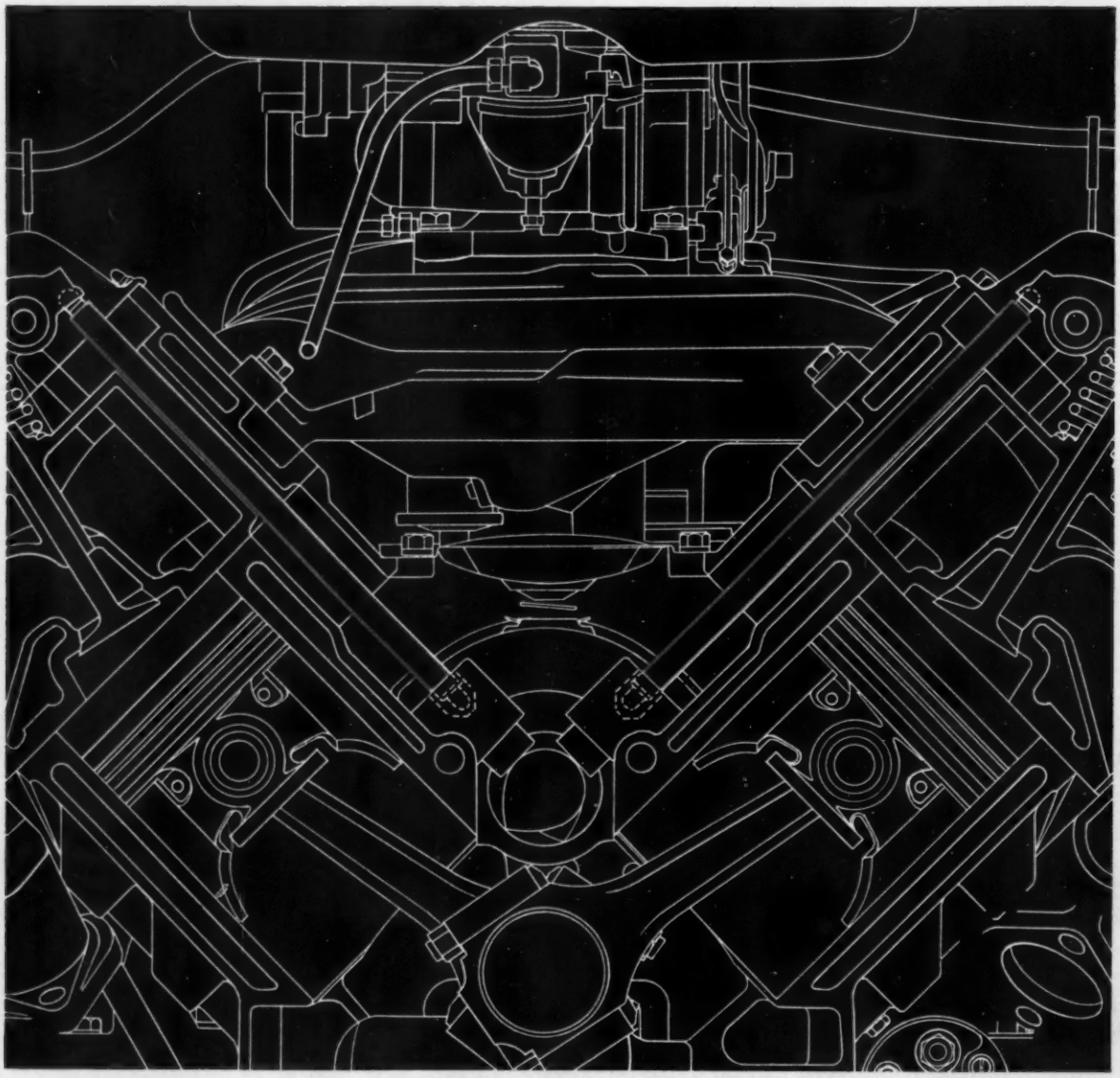
In addition to durability, improved vision in bad weather is provided by the fog cap, and quick day or night aiming is made possible by the E-Z Aim Platforms. Drivers, equipment and cargoes are safer at night behind Tung-Sol Vision-Aid Headlamps, and they cut lamp replacement costs in the bargain.

TUNG-SOL ELECTRIC INC.
Newark 4, N. J.

Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Montreal, P. Q.

TUNG-SOL®
No. 5440-S RUGGEDIZED
VISION-AID HEADLAMPS
WITH E-Z AIM PLATFORMS

Lightweight Bundy Tubing push rods



Long proved in heavy-duty truck engines, Bundy Tubing improves the performance of powerful V-8 engines by reducing cam load, increasing the efficiency of the entire valve train.

BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP



Bundyweld starts as a single strip of copper-coated steel. Then it's . . .



continuously rolled twice around laterally into a tube of uniform thickness, and



passed through a furnace. Copper coating fuses with steel. Result . . .



Bundyweld, double-walled and brazed through 360° of wall contact.



←

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

help new V-8's deliver full power!

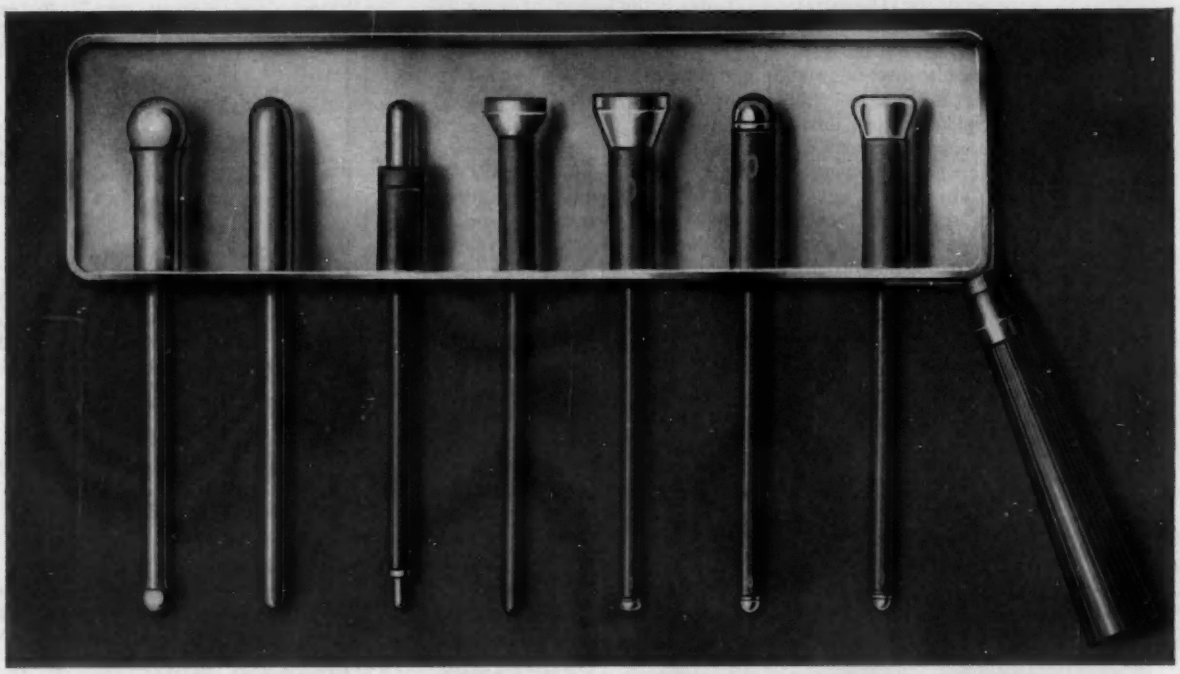
Exciting acceleration and flashing performance are trademarks of today's automotive engines. Since heavy, solid push rods reduce valve efficiency and rob new V-8's of power, many auto makers now insist on push rods of Bundy® Tubing.

Easily fabricated into strong, lightweight push rods, Bundy Tubing reduces cam load, increases the efficiency of the entire valve train. Engines "breathe" deeply, deliver full, designed-in power.

Cold-drawn to proper hardness and held to specified low-camber tolerances, Bundy Tubing is extremely fatigue-resistant, has high ultimate tensile strength. Unmatched dependability has made Bundy Tubing the standard for mechanical- or fluid-transmission applications in cars, trucks, and farm equipment. *In fact, Bundy Tubing is used on 95% of today's cars, in an average of 20 applications each.*

And at Bundy, you get even more than high-quality, low-cost tubing delivered on schedule. We offer free, expert engineering and design service, and fabrication facilities to mass-produce any tubing design to your exact specifications. For full information, call, write, or wire us today.

BUNDY TUBING COMPANY, DETROIT 14, MICHIGAN

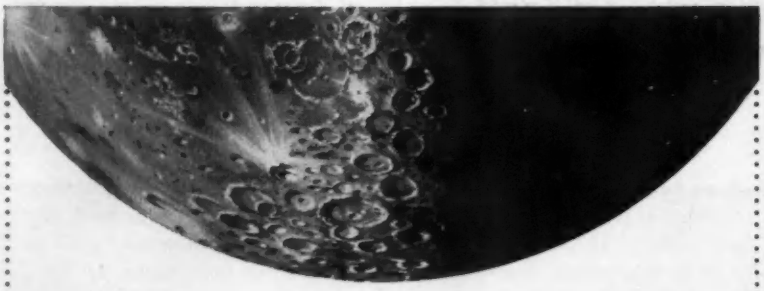


Because Bundy Tubing fabricates more easily than the material it replaces, you get more uniform, better finished parts. Bundy offers free design help and fast fabrication service, too.

BUNDY® TUBING

Bundy Tubing Distributors and Representatives: *Bala-Cynwyd, Pa.:* Rutan & Co., 1 Bala Ave. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *East Orange, New Jersey:* C. E. Conover & Co., Inc., 604 Central Ave. *Los Angeles 22, Calif.:* Pacific Metals Co., Ltd., 2187 S. Garfield • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South. **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY



Men who know

TURBINES, PUMPS, COMPRESSORS

Get in on the development of the most advanced high-speed rotary equipment ever built

Here's your opportunity to step up to a new, higher level of turbo-machinery technology—the Large Rocket Engine.

Whatever type of rotating machinery you know best, your experience could be extremely valuable in the important developments now going on at Rocketdyne. The seasoned and ambitious man who has cut his teeth on jet engines, steam or gas turbines, or other elements of rotating machinery, is urgently needed to apply mechanical principles to meet the increasing demands of power plant performance.

The combination of high speed, light weight, heavy loadings and exceptional pressures required in rocket engine work is leading to an entirely new breed of high-performance rotating machinery... and a new breed of engineer. You can be one of this advance guard of the turbo-machinery field—if you have the desire to build your professional status by accepting new challenges.

Rocketdyne is building high-thrust rocket engines for the nation's major missiles. You'll work with the leading producer in the nation's fastest growing industry. You and your work will be recognized as a vital part of the overall achievements. Testing facilities are among the world's finest. The power produced is beyond anything ever before thought possible. If you would like to tackle new assignments working alongside some of the finest minds in turbo-engineering, write and tell us about your background: A. W. Jamieson, Rocketdyne Engineering Personnel Dept. SAE-4, 6633 Canoga Avenue, Canoga Park, California.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

BUILDERS OF POWER FOR OUTER SPACE



Applications Received

The applications for membership received between Feb. 10, 1957, and March 10, 1957, are listed below.

Atlanta Section

John S. Leedy.

Baltimore Section

John Richard Clark.

British Columbia Section

Ralph Faulkner.

Buffalo Section

George B. Basil, James F. Muir.

Canadian Section

Lloyd S. Bergen, Herbert V. Coleman, Robert M. Crossan, Frank C. Cullimore, D. V. Dickie, James Gilbert Dow, C. H. Harvey, Von R. Kaufman, James N. Matthews, J. George Slubicki, Victor J. Trickett, Allen Grant Warner.

Central Illinois Section

William R. Griffith, Glenn A. Ball, Harrison Fredrick Cox, Donald C. Kaiser, William J. O'Shaughnessy, Robert N. Stedman, Jack M. Tollefson.

Chicago Section

E. P. Epler, Joseph R. Kirk, Ernest J. Leidberg, Richard L. Lewis, David C. Miller, John E. Onnen, Thomas W. Perry, Robert Maurice Riley, Wade E. Underwood, Vernon C. Westberg, Ralph D. Wysong, Leonard D. Zemek.

Cincinnati Section

William G. Cornell, Eugene Gatewood, John E. Gyarfas, Kurt P. Halbert, Karl W. Kalb.

Cleveland Section

Robert E. Alexander, Dean R. Christian, William F. Collier, William E. Huber, Henry O. Kirkpatrick, Comdr. Philip P. Lucy, Peter M. Molyneux, Charles O. Parratt, John T. Simone, Albert E. Taylor, Norman B. Thornhill, Paul Weisenbach.

Dayton Section

John B. Day, Jr., John W. Spencer.

Detroit Section

Jose R. Alvarenga, Edmund T. Barbour, Earl A. Barden, Tom K. Barton, Edward J. Bayus, Burwyn B. Bender, Edward E. Bozyk, William Breuer, Arthur Causley, John B. Demchak, Lawrence J. Dranchak, John L. Frost, Perry B. Hartupee, William T. Holman, Jr., Robert W. Hurley, Robert Alfred



Over swamp, sand and snow, FWD TERACRUZER delivers Fire Power with BLOOD BROTHERS UNIVERSAL JOINTS

Matador guided missiles are transported virtually anywhere by the new Air Force TERACRUZER, designed and built by The Four Wheel Drive Auto Company and equipped with "pillow" tires by Goodyear Tire and Rubber Company.

This revolutionary vehicle required universal joints that could "take it" over the roughest terrain. That's why the builders specified Blood Brothers Universal Joints — known for precision balance, dependability and long life.

You too, will find that on standard or special vehicles — whatever your requirements — Blood Brothers Universal Joints deliver superior performance.

Next time you're up against a universal joint problem, write or call Blood Brothers. Our engineers will gladly cooperate with you.



Selected for this Four Wheel Drive Auto Company project, a dependable Blood Brothers Universal Joint functions off the transmission of the TERACRUZER.

BLOOD BROTHERS
MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS
AND DRIVE LINE
ASSEMBLIES

Applications Received

Continued

Husen, Alfred L. Hylton, Henry A. Jewell, Robert E. Klare, John Molyneaux Lay, Cameron Lombard, George Peter Manasa, Robert M. Mello, Joseph Eugene Mila, Jack Mohr, James L. Molnar, Wilbur C. Nelson, Phillip J. Oeth, Sabatino Sam Petrilli, Laurence M. Phillips, Robert A. Rogers, James S. Ross, Donald F. Rundle, Jerold Walther Scheel, George Sobol, Charles F. Sporman, Paul E. Taylor, Ross E. Taylor, John J. Torsok, Wallace E. Watkins, George E. White, Mansel O. Wiley, Alverson B. Williams, John J. Wisniewski.

Indiana Section

Richard Arthur Doversberger, Jack Lee Grose, Glenn F. Whiteley, Dean L. Williams.

Kansas City Section

Willard G. Betteridge, Charles M. Botkin, George F. Moore, John A. Wood.

Metropolitan Section

Frank P. Crowley, Aaron J. Keeperman, Robert A. Keyes, Pierre Maluski, Henry Martin, Richard R. Staebler.

Mid-Continent Section

Vaughn E. Flinn.

Mid-Michigan Section

Hubert L. Curtis, F. Robert J. Fowler, K. M. Hart, Edward A. Idzkowski, Roderick W. Kallgren, Michael J. Koenig, Gerald W. McArthur, Leonard L. Osgood, William C. Robertson.

Milwaukee Section

Robert T. Johnson, Donald J. Surfus, John V. Wiman, Harry E. Wolcott, Robert E. Zuleger.

Mohawk-Hudson Section

Clifford E. Bowdish, Jr., John S. Ippoliti.

Montreal Section

John Charles Morris, Harold A. Ross, Ronald H. Whiteside, Kenneth W. Wood.

New England Section

Donald Lee Paster, James M. Stewart.

Northern California Section

Frederick W. Abraham, Joseph F. Atkins, Jr., Richard C. Bouma, Reuben E. Lagerstrom, William B. Richards, Jr., Harold B. Uhlig.

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Cast Aluminum Tooling Plate

for Unexcelled MACHINABILITY

plus

STABILITY

plus

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plus

VERSATILITY

plus

AVAILABILITY

plus

LOW COST



PIONEER 921-T Cast Aluminum Tooling Plate is the *universal* tool and jig material, lending itself to fast, precise fabrication at great savings in time and material while maintaining tolerances within ±.0005" in machining operations. It is easily sawed, tapped, milled or welded; is stable to the highest degree; weighs 60-70% less than steel, and is relatively free of porosity and casting defects. Write to receive periodic bulletins on applications and technical case histories.

Pioneer 921-T is available through these suppliers:

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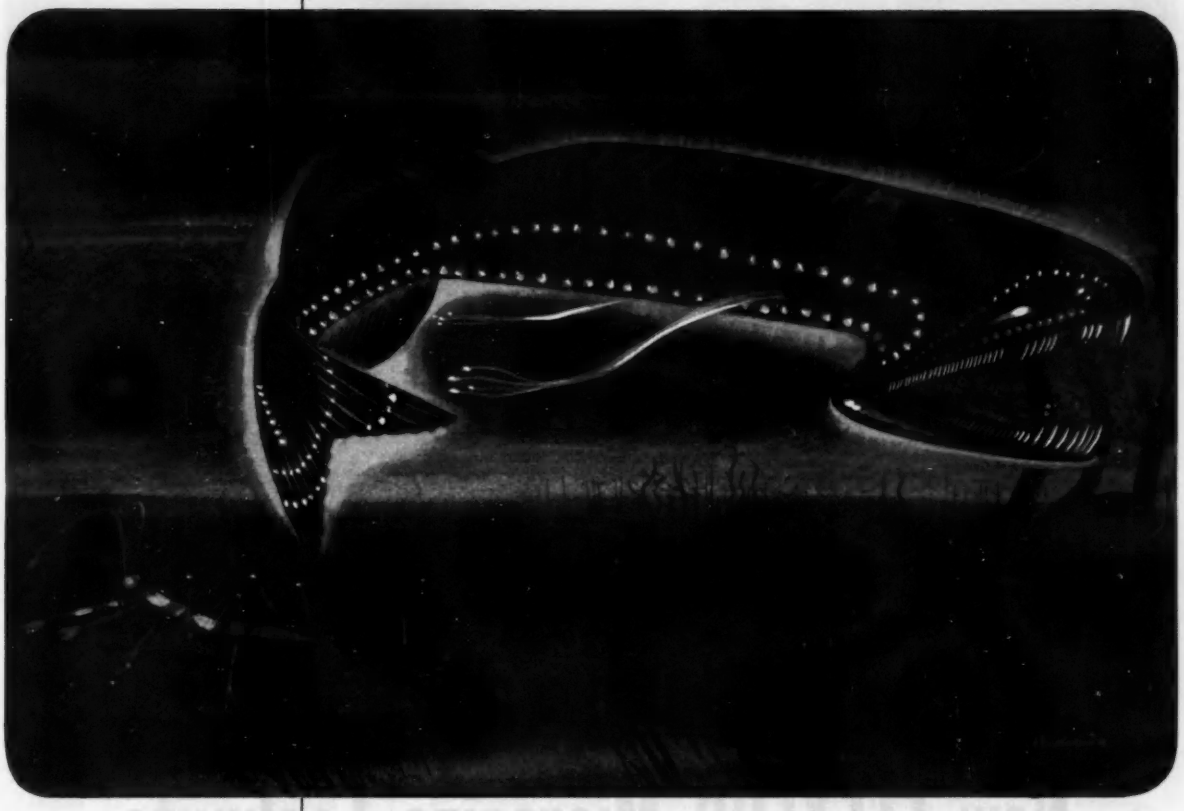
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The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

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In the creatures of the deep sea, Nature has provided us with many examples of structures designed for their environment. We at JPL are faced with a comparable problem in designing missile structures to withstand the forces of their environment. In addition, our solutions must be produced in far less time than Nature allows herself.

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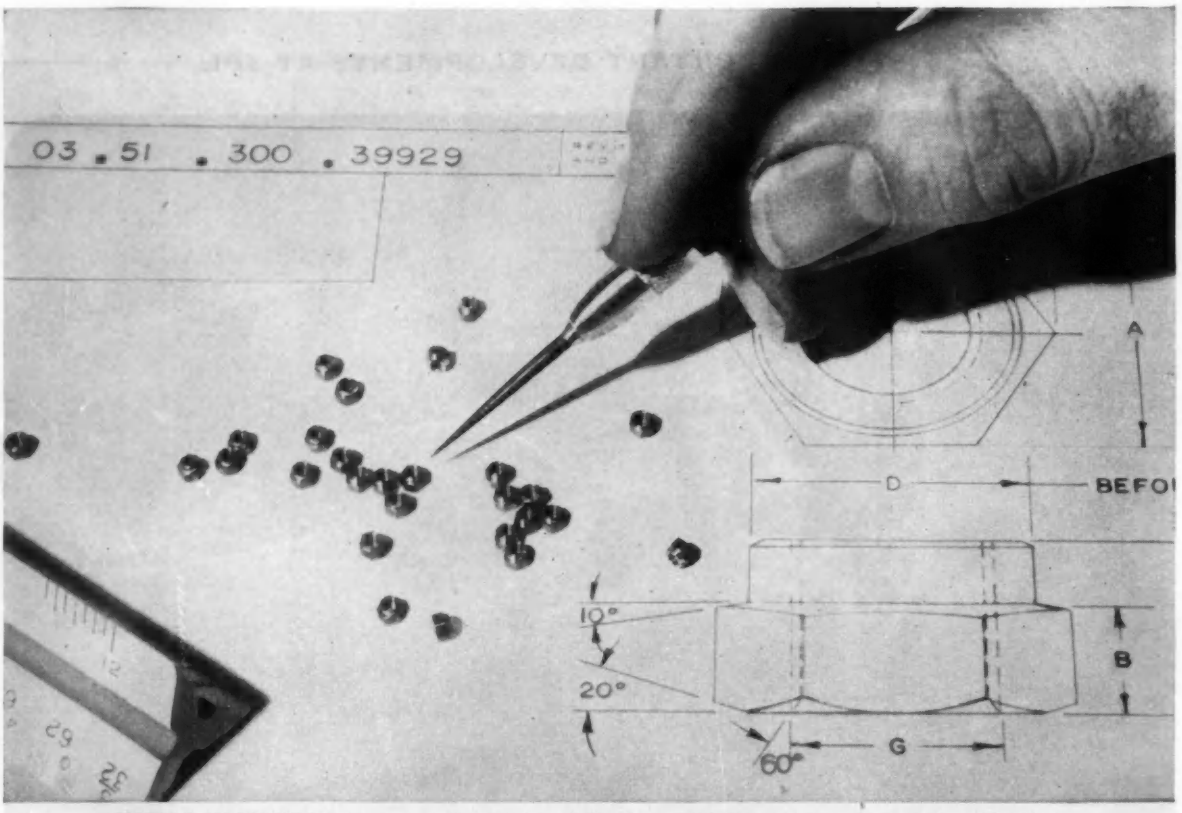
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FLEXLOC MICROSIZE locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

New FLEXLOC Microsize Locknuts

Now available in Alloy Steel, Stainless Steel, Brass and Aluminum for lighter, more compact designs

SIZE	Across Flats		Hex. Height	Across Corners	Height
	MAX.	MIN.	REF.	MIN.	REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

SPECIFICATIONS: Available in brass (plain or cadmium plated) and aluminum (plain or chemically treated), for temperatures to 250°F; in alloy steel (plain or cadmium plated) and 18-8 stainless steel (silver plated) for temperatures to 550°F.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

Microsize FLEXLOCS have all the advantages of larger FLEXLOCS. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil won't affect these Microsize FLEXLOCS. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

For complete information on Microsize FLEXLOCS, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL Co., Jenkintown 55, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA

Applications Received

Continued

Albert A. Mueller, Jr., Raymond F. Stelzer, M. George Zornada.

Southern California Section

Clifford E. Cole, Karl E. Giesler, Charles G. Graef, Harry Jaffe, H. Linden Orgill, Donald Jack Warren.

Southern New England Section

William E. Aksomitas, Robert F. Anasoulis, Thomas J. McIntyre, Edward F. Potocki.

Spokane-Intermountain Section

Donald E. Bruce, LeRoy V. Irwin.

Texas Section

Raymond Courtney Burdick, Joe C. Ferbis, Beauford D. Haynes, Jesse B. Holman, Jr., Starr L. Pitzer.

Texas Gulf Coast Section

C. J. Benefiel.

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James D. Andersen, Bernard W. Carlson, Alexander Kaminski.

Washington Section

George H. Baxter, Samuel Frank Follett.

Western Michigan Section

Dan Blaine Kuiper.

Wichita Section

Gary C. Himes.

Williamsport Group

Tom G. Conway, William B. Russell, Earl L. Wilkinson.

Outside Section Territory

Bruce B. Burket, J. F. Finn, Jr., Lloyd L. Gardner, Arthur L. Heffelfinger, C. O. Johnson, Henry W. Morriss, Paul Edward Quinn, Wilbur C. Rumph, John Paul Stapp, Steve Urosevich, Robert P. Wolfe, Woodrow I. Workman.

Foreign

R. S. Bahadur, India; Jean-Hubert Frings, Belgium.



Fabricon Reinforced Plastic Moldings permit GREATER FREEDOM OF DESIGN!

Take a good look at many of today's smart new automobiles and you'll find that an amazing number of parts are now being made of reinforced plastics . . . *custom molded by Fabricon!* Heater housings, seat back panels, bonding strips, garnish moldings, just to name a few. What's more, if you look around, you'll also find that Fabricon reinforced plastic moldings are playing an increasingly important role in the design and manufacture of many other products, too. And for very good reasons!

1. Because the premix compounds are scientifically developed and produced by Fabricon to meet the specific requirements of each individual application.

2. Because basic materials selected are processed by Fabricon's special laboratory controlled methods to assure proper distribution of fiber reinforcements throughout each finished molded part.

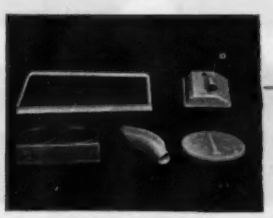
3. Because the greater uniformity of physical characteristics thus obtained permit the use of Fabricon reinforced plastic moldings on countless applications generally considered impractical or, indeed, impossible just a few short years ago. And . . .

4. Because ease of molding plus *lower tooling costs* permit efficient, economical production of intricate, complex parts. Parts which require no costly secondary or assembly operations . . . which in turn invariably permits greater freedom of design!



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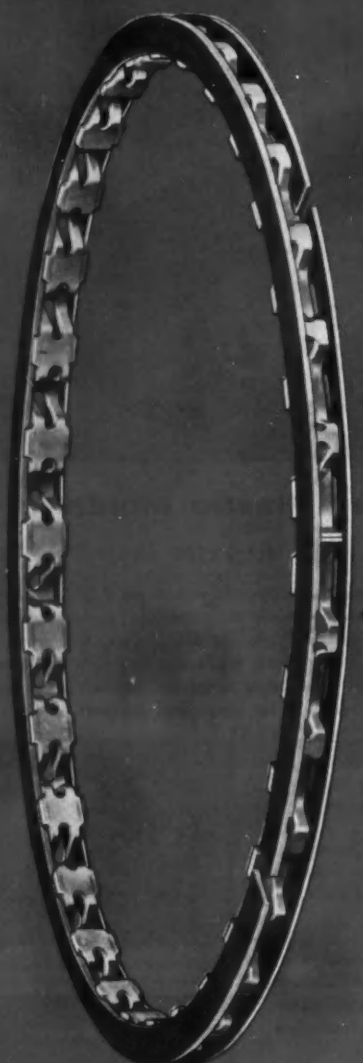
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Reinforced Plastic Moldings • Plastic Impregnated and Coated Materials

Here's why stainless steel is much better than carbon steel for oil ring expanders:



SS-50U

STAINLESS STEEL RETAINS TENSION UNDER HEAT

Austenitic stainless steel holds its room-temperature tension at engine operating temperature much better than the carbon steels that have served so long so well.

STAINLESS STEEL RESISTS CORROSION

Stainless steel is impervious to the corrosive elements found in internal combustion engines. Carbon steels, under the corrosive effects of combustion gases, are subject to acid attack which encourages breakage, and to deposits of carbon and varnish, which lessen efficiency.

STAINLESS STEEL RESISTS WEAR

Because of its work-hardening characteristics, this stainless steel gets harder as it wears, developing more resistance to wear. This makes Sealed Power's new stainless steel expander outwear carbon steel expanders.

THE NEW SEALED POWER SS-50U STAINLESS STEEL OIL RING . . .

This is the first oil ring designed to take full advantage of the exceptional properties of austenitic stainless steel. Its uniform high radial pressure against the cylinder wall assures maximum oil control. Its axial pressure produces effective side-sealing action, preventing oil waste and "smoking" under high vacuum. Its circumferential pressure makes the expander independent of groove depth, conforms to the bore, makes installation easy.

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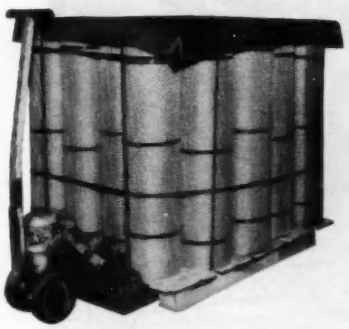
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Largest Producers of Sealing Rings for Automatic Transmissions and Power Steering Units







How **REYNOLDS** packs new savings into wire cloth shipments

• Palletized packaging for wire cloth, successfully developed by the Reynolds Wire Division of National-Standard, is now saving customers plenty of time and dollars.

Note in the photographs how rolls of slit and full width material are both mounted on non-returnable pallets. Advantages and savings accrue all along the way.

For example, there's far less chance of damage in shipment. And think how much faster, easier, these unit loads can be handled on arrival . . . in and out of storage . . . and right to production operations.

So chalk up another extra for Reynolds' service . . . and find out what this new packaging method can mean to you! Find out, too, what Reynolds means by quality control and uniformity in wire cloth manufacture. It pays.

NATIONAL NS **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *fine wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *high and low carbon specialty wires*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*



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SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.



How Mayari R thwarts corrosion in these refuse loaders

Ashes, rubbish, garbage, boxes, crates, even Christmas trees — all are gobbled up and chewed to a pulp inside the cavernous bodies of these welded Roto-Pac refuse loaders. What a happy hunting ground for corrosion and abrasion!

City Tank Corporation, Corona, L. I., N. Y., makers of Roto-Pacs, stave off corrosion and abrasion by building the sides, roof and floor of the body with Mayari R high-strength, low-alloy steel. Mayari R resists abrasion substantially longer than carbon steel, and has five to six times greater resistance to atmospheric corrosion. It also welds just about as easily as carbon steel.

These three properties have led many vehicle manufacturers to take advantage of Mayari R in building their product. So has its high yield point (50,000 psi for material up to and including ¾ in. in thickness) which permits the use of lighter structural members for sizable reductions in deadweight.

Catalog 353 contains important technical data on Mayari R, as well as scores of illustrated case histories on specific Mayari R applications. If you would like to have a copy, just telephone or send a letter to the nearest Bethlehem district sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

Mayari R...High-Strength, Corrosion-Resisting Steel

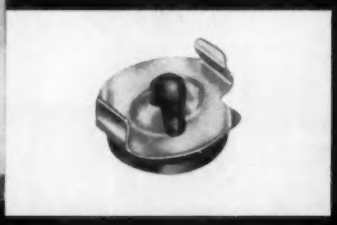
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THREAD CUTTING FASTENER
HOLDS TIGHT TO CURVED SURFACES

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- Re-Usable
- Self-Locking
- Vibration-Proof
- Spring Take-Up

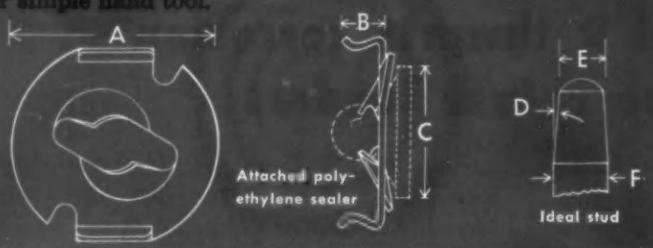




Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT'S unique T.C.F. can be used in many other applications which require a spring take-up fastener that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity*, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.



Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6°/4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6°/3°	.160 .150	.192 .184	20 – 30 Inch lbs.	400 lbs.



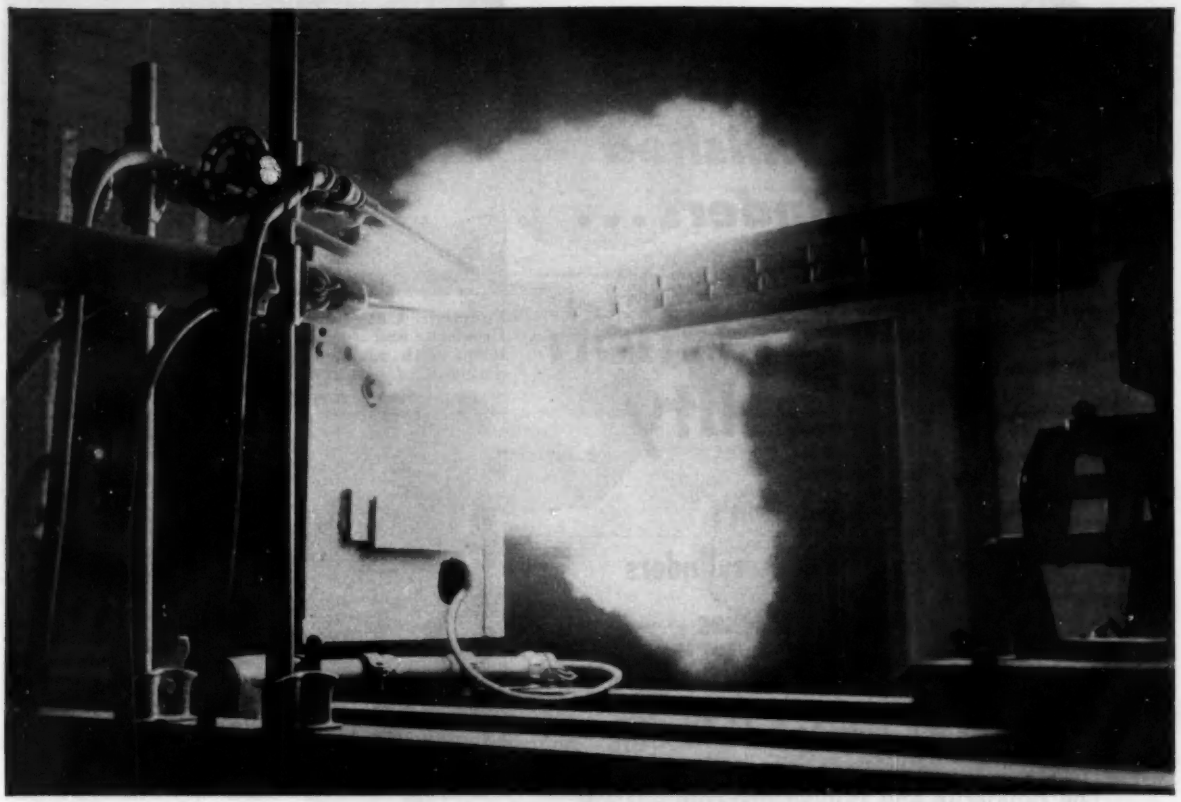
Manufactured by
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San Leandro, Cal.

DOT T.C.F.
Patent Pending

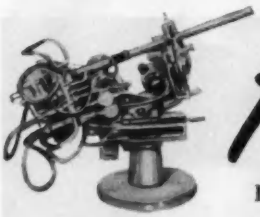
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A LOW-POROSITY, WEAR-RESISTANT ALUMINUM OXIDE COATING



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Flame-Plating by *Linde*

Trade-Mark

LINDE's Flame-Plating method of coating metal surfaces now provides extra wear resistance for parts subject to extremely hard wear and high temperatures. This new high-purity aluminum oxide coating, blasted from the Flame-Plating gun, builds up on the workpiece in desired thicknesses from .002 to .040 inch. With a porosity of *less than 1 per cent*, the aluminum oxide coating can be used at temperatures up to 1750 degrees F.

The hardness of aluminum oxide coatings, Flame-Plated by LINDE, ranges from 1000 to 1200 VPN. Metallurgical properties of the base metal are not modified by the Flame-Plating process because the part being plated always remains at a temperature of 400° F. or below. The bond between coating and base metal is exceptionally strong with aluminum. Aluminum oxide coatings can be used in as-coated condition (approximately 120 microinches rms), or finished to better than 1 microinch rms.

Flame-Plated coatings of aluminum oxide provide resistance to wear, and to chemical action in high temperature applications. Applications are found in thrust bearings, pump plungers, thermocouple tubes, gas turbines, guided missiles, and other devices. Either aluminum oxide or tungsten carbide can be Flame-Plated on most metals. If you have a special wear problem, LINDE's Flame-Plating Department will gladly help you to reach a solution. Write to "Flame-Plating Department SA-4."

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

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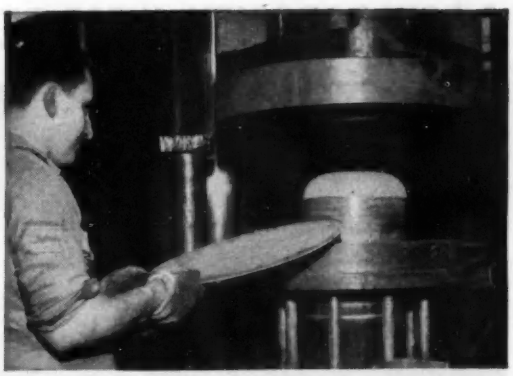
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Bonderite and Bonderlube, by more efficient lubrication, help plants reach new production levels, get more efficient and economical production, and achieve better, more uniform quality.

Parker's cold forming experience in many plants and on many products is available to apply on your cold forming problems at once. Write or call today.

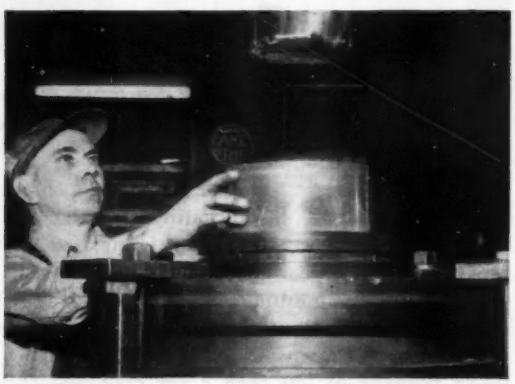




Cupping: Flat CO_2 cylinder blank, treated with Bonderite and Bonderlube, is changed into cylindrical form, with maximum of about 45% reduction in diameter of blank.



First reduction: Diameter of cup is made smaller and length increased without major change in wall thickness.



Second reduction: Final diameter of part with respect to length determines number of reductions required. Photos courtesy NORRIS-THERMADOR Corporation, Los Angeles, California.

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Here is a handful of ELASTIC STOP® nuts. Each has ESNA's familiar red locking collar . . . is self-locking and vibration-proof. Each is a readily assembled, one-piece unit. Each provides positive protection against thread corrosion . . . prevents liquid seepage along bolts. Each is made from the finest of raw materials. Each is exactly controlled as to finished dimensions, class of thread fit and finish. Each is now in use on critical applications, with a record for uniform high quality that is unmatched.

Most of them are standard parts. Some originated as the result of a specific request for ESNA's help with an important fastening problem.

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Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin ☐ Here is a drawing of our product. What self-locking fastener would you suggest?

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City_____ Zone_____ State_____



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retain their original properties even after long exposure to temperature extremes that would quickly ruin organic rubber.

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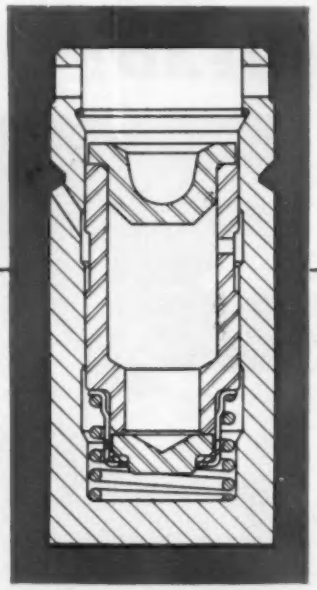
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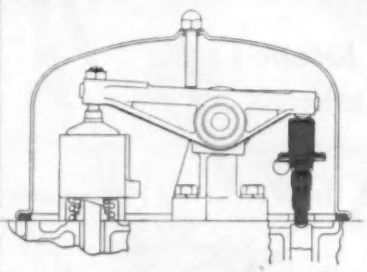
CHICAGO SPRING-LOADED FLAT VALVE HYDRAULIC TAPPET

Designing valve gear?

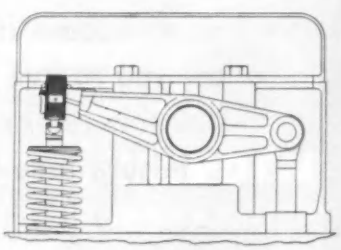
We invite you to use these specialized CHICAGO services



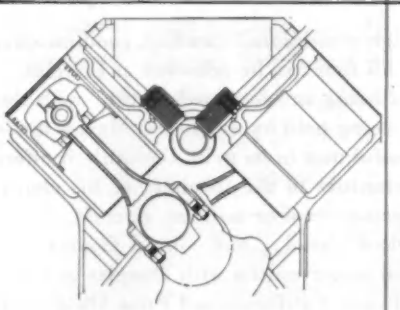
INSERT TYPE ROCKER ARM UNIT



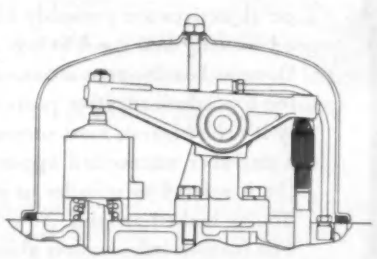
PUSH ROD TYPE FOR COMPRESSION RELEASE APPLICATION



THREADED TYPE ROCKER ARM UNIT



V-8 AUTOMOTIVE HYDRAULIC TAPPET APPLICATION



HYDRAULIC UNIT ON END OF PUSH ROD

Design

of complete valve gear installations for any type of engine . . . passenger car, truck, tractor, diesel, aircraft or industrial.

Development engineering

based on years of specialized experience in valve gear problems. The skills of our engineers will prove a valuable addition to your own engineering staff.

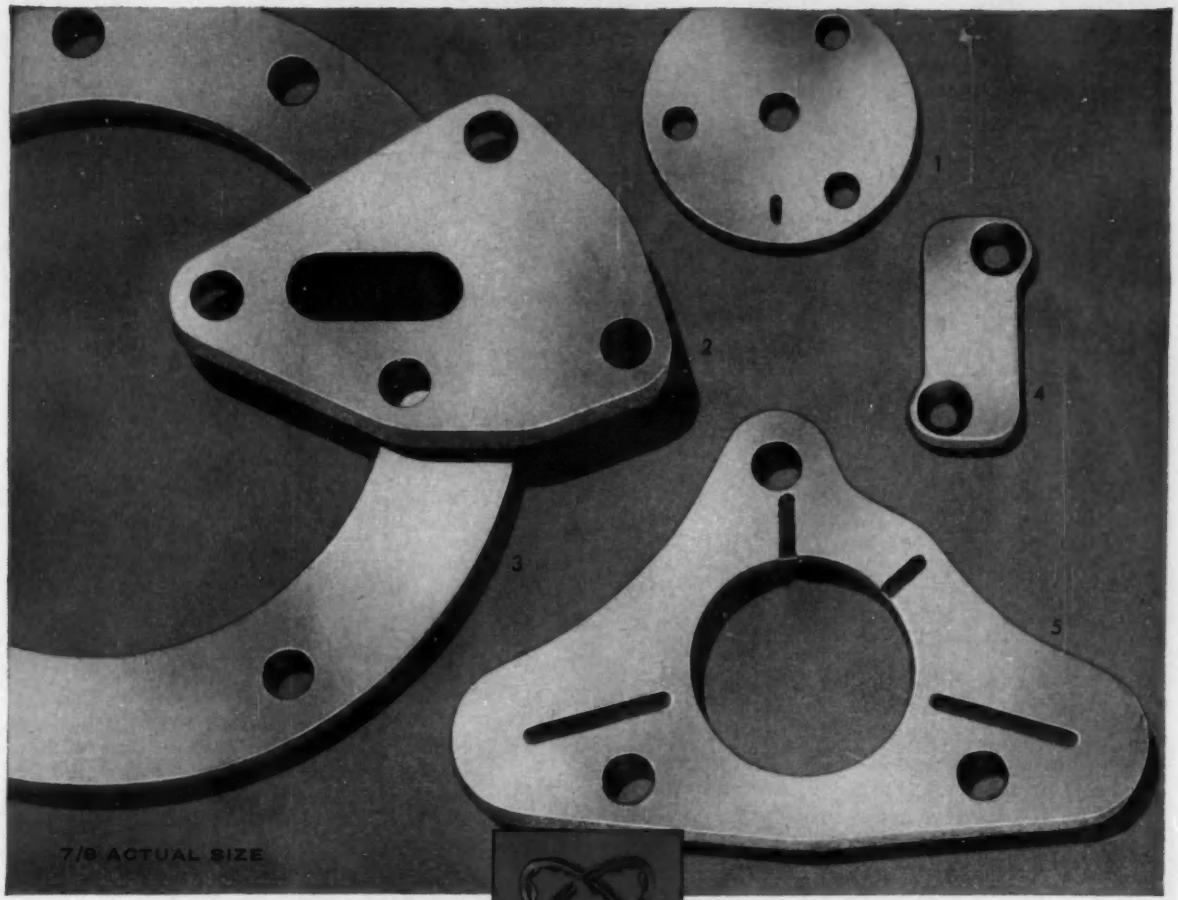
Tappet manufacturing

CHICAGO's facilities insure precision-manufacturing, scientific testing and rugged, trouble-free performance in every tappet. We will welcome the opportunity to serve you.

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DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872

2521 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS



From the producer of piston rings  **used in 1 out of every 3 new cars . . .**

Precision castings at "captive cost"

Muskegon's Sparta Foundry now offers the finest in small precision castings–at surprisingly low cost! Consider these advantages:

1) Complete service from design conception to finished product.
2) Ready-to-install parts–with surface finishes and flatness to your specifications; with width tolerances to within plus or minus .001"–completely deburred, drilled, reamed or tapped.
3) Castings of high carbon cast iron, high strength alloy cast iron, cast bronze and sintered powdered metal parts–plus Muskegon developed Spartaloy metals to meet unusual heat, wear and corrosion needs.

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WRITE FOR YOUR FREE SAMPLE KIT

This assortment of miniature casting samples shows what is being done in precision castings . . . what metals can be used . . . how they can be formed and machined for you. Write today! Sparta Foundry Co., Sparta, Mich.



Since 1921 . . . The engine builders' source!

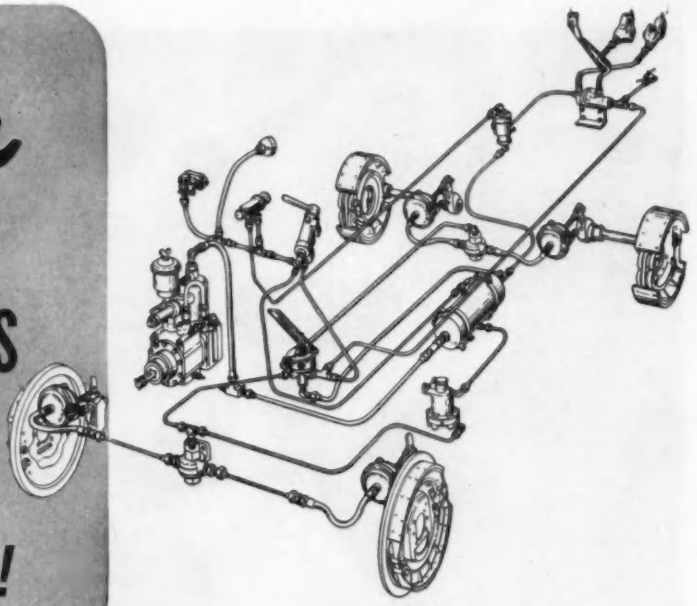
MUSKEGON Piston Ring Co.

PLANTS AT MUSKEGON, MICHIGAN SPARTA, MICHIGAN
ROTARY SEAL DIVISION PLANTS AT SPARTA, MICHIGAN CHICAGO, ILLINOIS

Wagner

STRAIGHT AIR BRAKE SYSTEMS

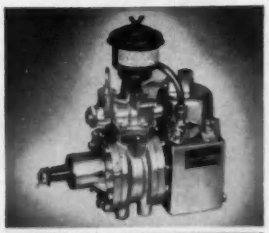
provide safe, sure stops for cam type brakes!

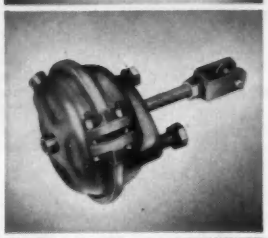


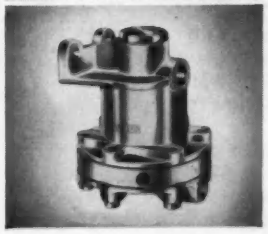
Wagner Straight-Air Brake actuating systems give cam type foundation brakes the ability to make quick, safe stops—completely controlled by the driver. They are furnished plenty of air at all times by the Wagner Rotary Air Compressor. The actuating units and application valves are *positive* in operation—performance-proved on many thousands of installations.

Wagner Air Brakes are the product of more than thirty years of brake engineering experience—gained in the designing and building of brake systems and brake parts for the automotive industry. When you equip the heavy-duty vehicles you manufacture with Wagner Air Brakes, you are adding safety and low-maintenance features that build customer acceptance.

Get all the facts on the Rotary Compressor and other features that make Wagner Straight-Air Systems so dependable and so safe. Write for your free copy of Catalog KU-201—it gives all the facts you should know about Wagner Air Brake Systems.







features include:

WAGNER ROTARY AIR COMPRESSOR—provides an abundance of air at all times. Its cool operation prevents carbon formation in air lines. Uniform torque load and smooth operation with moderate stresses assure long compressor life and long belt life.

WAGNER BRAKE CHAMBERS—have diaphragms of neoprene rubber bonded to high-tensile-strength nylon fabric for superior oil resistance and maximum strength and flexibility. Available with or without push-rod seal. All brake chamber parts are of corrosion-resistant material, or are plated to prevent rusting. Wagner Brake Chambers are interchangeable with all clamp type and bolt type units equipped with standard mounting studs, regardless of make.

WAGNER MOISTURE EJECTION VALVE—automatically keeps air reservoirs clean and dry by ejecting accumulated moisture with each average brake application—without causing a noticeable drop in tank pressure.

K57-11



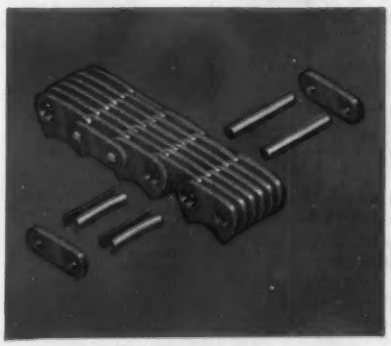
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More than 80,000,000 durable Morse Timing Chains have been used by the auto industry. Now specified as original equipment for 21 out of 23 passenger cars, Morse Timing Chains give car owners steady, reliable service—operate quietly and smoothly, with positive timing.

WHY 21 OUT OF 23 1957 CARS CHOOSE TIMING CHAINS BY MORSE



This new Morse Timing Chain, above, designed to meet the needs of higher horsepower 1957 cars, features spring-bushing joint construction for longer service, smoother and quieter operation. The new bushing cuts joint vibration by reducing tendency to "whip", provides for take-up of slack, and serves as a damping device to minimize noise. Ask for Catalog C60-51.

Chances are your new car will have a Morse Timing Chain. For sound reasons, too. Morse Timing Chains are precision-built—like fine watches—to give car owners longer service life and freedom from maintenance worries.

In Morse Timing Chains, sure dependability is built right in!

If you have a timing chain problem, original equipment or replacement, it will pay you to get in touch with Morse. For full information—and ready engineering help—phone, wire or write *MORSE CHAIN COMPANY, DETROIT, MICHIGAN; ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Ill.*

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new clutch is adaptable to all torque needs

* By varying the number of springs in multiples of three, *Lipe* can adapt the five sizes of its new Direct Pressure Clutch to all engines developing from 300 to 1300 ft-lb of torque. For example: depending on its service, a 15" DP can be furnished with its full complement of 27 springs . . . or only 24, 21, 18, or 15.

The advantages of this unique *Lipe* feature are obvious. Manufacturers will find it may be possible to standardize on a single clutch size to meet *all* torque requirements. Fleet Owners will notice the significant reductions in maintenance since clutches won't be under- or overloaded.

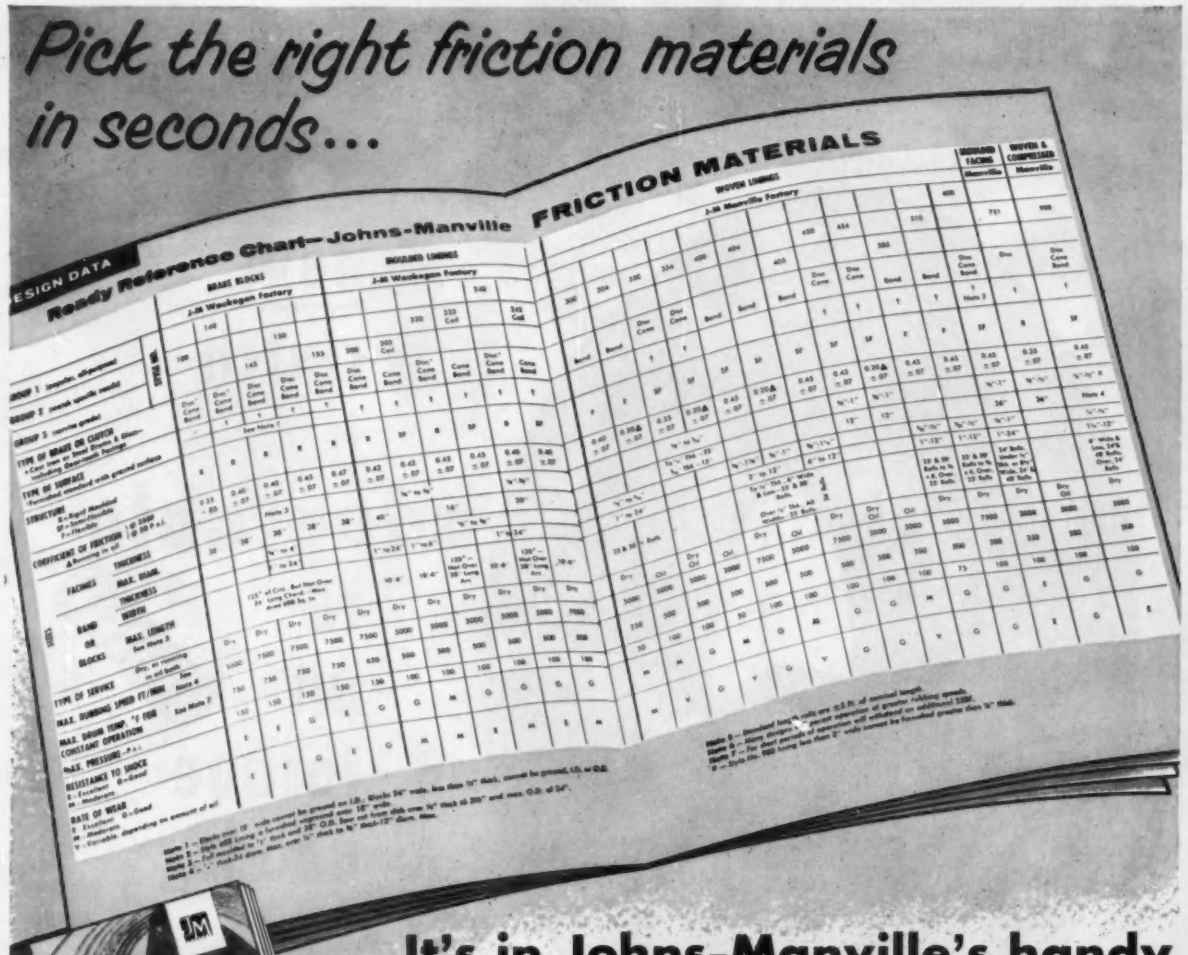
Write for full information.

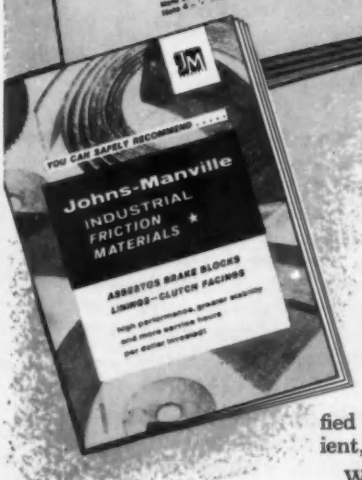
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WHEN YOU ENCOUNTER a design problem that involves the control of motion, you'll find this new, ready-reference book about Johns-Manville Friction Materials a big help. Its sixteen pages are loaded with specific design data, presented in simplified table form, that you'll find convenient, accurate and easy to use.

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Major and vital components for jet engines

produced by Fairchild Engine Division—*in mass quantity, to highest precision standards*

Through skill, experience and production efficiency, Fairchild Engine Division manufactures such precision parts as turbine wheels, frames, diaphragms and turbine buckets for the jet engines of some of America's most powerful fighters and bombers. Subcontracting many other parts as well, Fairchild Engine Division has proved dependable production performance in mass quantity to highest precision standards.

Now in Fairchild's new plant at Deer Park, Long Island, this production capability is increased even more, and will be put to work wherever necessary to serve today's ever expanding aviation industry.

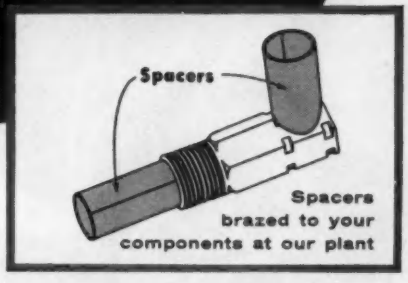
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Spacer tubes save time and money for their users

In these rolled steel spacer tubes we can offer you infinite design variations, to do a multitude of industrial jobs, at attractive costs. They are furnished ready for immediate assembly, to your exact dimensions. They eliminate costly cut-off and deburring. They are a money-saving substitute for iron pipe, tubing or mechanical parts, reduce raw material handling, scrap and inventory. They can be copper-brazed to your other components. Now used in hundreds of automotive, appliance, farm implement, wheel goods and other applications. Complete engineering service. Write for free catalog.

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Cushioned impact of "stops" and "starts"



Self alignment of springs, frame, and axles



Load balance control



Sidesway control



Shock absorbing action

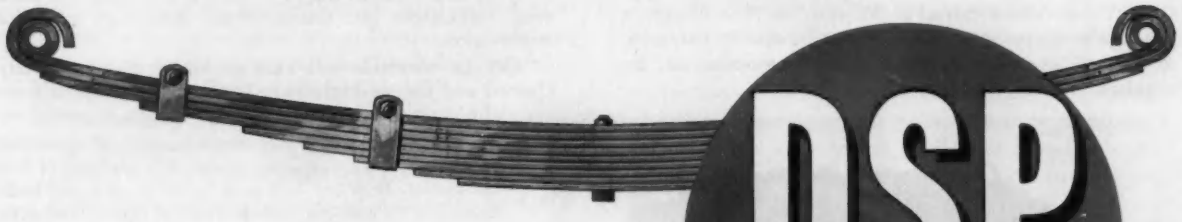
You get all these BUILT-IN FEATURES

Plus

basic leaf-spring economy for both manufacturer and customer

Leaf springs can be designed to fit any desired ride condition.

In every instance, they will also include the "built-in" features shown above PLUS the basic economy inherent in leaf springs.



DSP Leaf SPRINGS

DETROIT STEEL PRODUCTS DIVISION

OF *Fenestra* INCORPORATED

1500 Trombly Avenue, Detroit 11, Michigan

SINCE 1904—ORIGINAL EQUIPMENT ON CARS, TRUCKS, CABS, BUSES, TRAILERS

Better Engine Operation with Oil Coolers



Heat dissipation in limited area accelerated by new, plate-type unit

The ever higher performance being built into modern engines is creating new problems in heat dissipation. Engine efficiency, pressures and operating speeds have increased. So have operating temperatures of the engine parts. But the surfaces and area available for dissipating heat may be unchanged or even smaller. Therefore, more heat is drawn into the lubricating oil of the engine.

Although friction losses in percent of total power output are dropping, the absolute rate of heat generated has gone up. This heat may exceed temperatures which the bearings are designed to resist and may rise to destructive levels.

In commercial vehicle, marine and industrial engines, heavy work loads are usually frequent or constant enough to require an oil cooler to maintain viscosity and to augment heat rejection. Such a unit may be attached to the engine or built into the engine block.

LARGE CAPACITY IN SMALL UNIT

To facilitate concentrated heat dissipation in a small space, Long Manufacturing Division of Borg-Warner Corporation has developed a compact, plate-type heat exchanger with large heat rejection capacity for its size. The unit is applicable on or in any engine requiring lubricant cooling. Current applications extend to 400 btu/pm. The element's rectangular shape is proportioned to be readily adaptable to a small aperature in the block where water can be circulated.



Photo courtesy Gray Marine Motor Co.

The Long engine oil cooler, installed here on a new marine engine, is small, unobtrusive, easily accessible.

It can also be used for any oil cooling application, such as in transmissions, torque converters and hydraulic presses.

The high efficiency of this cooling element lies in the diagonal flow path of the oil across the plates, utilizing the maximum possible length of the unit. Location of the fittings gives high velocity turbulence and effective oil distribution.

Spacers are placed between the plates to allow free circulation of the cooling water around this core. The assembly is then brazed into an integral structure. Counter-flow paths of the oil and water assure maximum heat exchange efficiency.

The turbulators are designed to minimize the pressure drop across the plates. Ingenuity in designing flow paths and stack arrangements of a single design element, according to the operating requirements, contributes to the economy of the unit. Any reasonable number of plates may be assembled in parallel, in series, and in parallel series.

RUGGEDNESS AT LOW COST

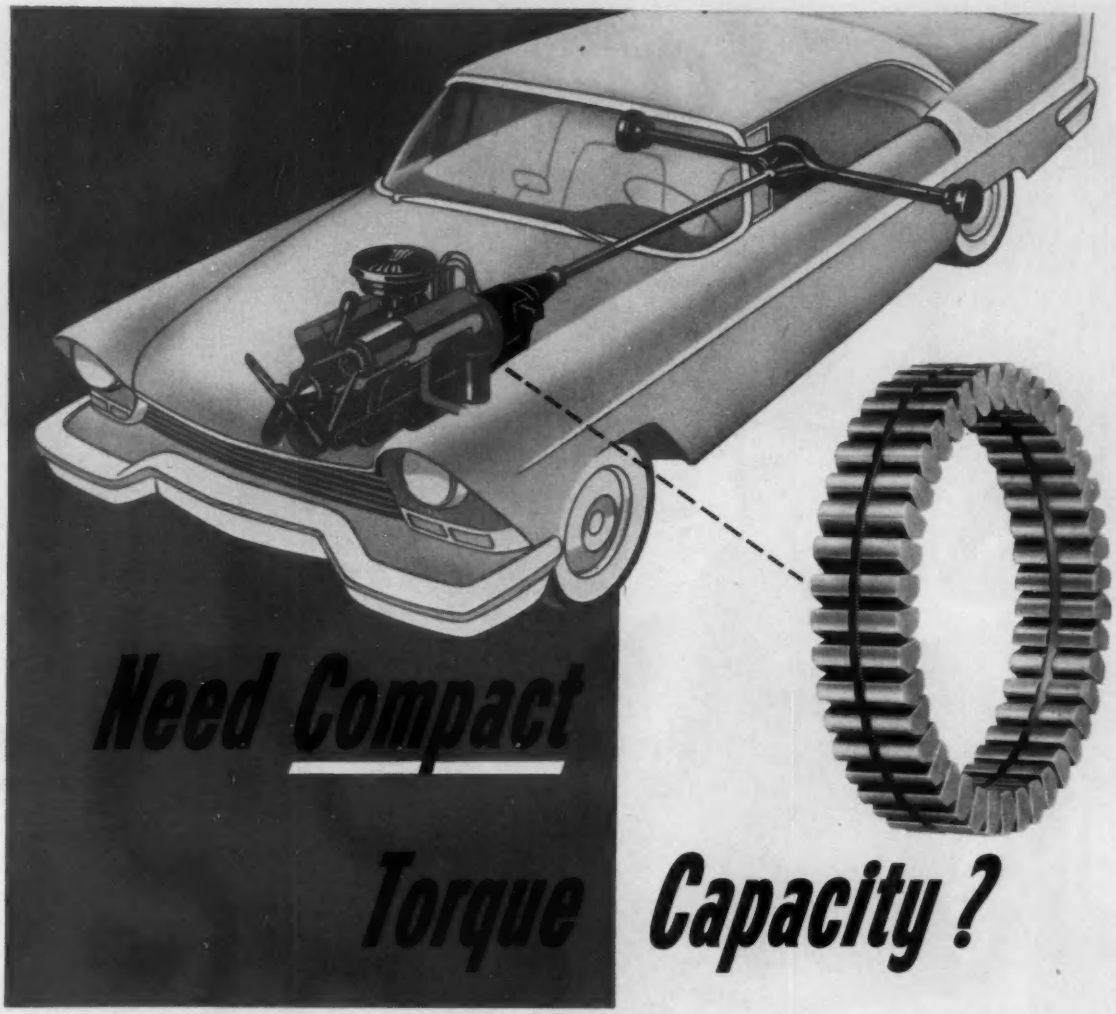
Manufacturing the casing (in accessory applications) from steel stampings instead of fabricating it from castings is a unique, cost and weight saving feature. Paint protects the exterior while the waterside is clad with rust- and corrosion-resistant cupronickel. The plate shells enclosing the mild steel turbulators are formed from stampings of solid cupronickel.

On the waterside this heat exchanger may be readily cleaned and the multiple-plate core can be removed from the casing without disturbing the water connections.

Traditional Long engineering and craftsmanship assures the quality, efficiency and dependability of this oil cooler. It is the first in a series of new products from this 53-year old manufacturer of heat exchangers, clutches and torque converters.

An engineering bulletin, including basic heat transfer and pressure drop charts from performance tests at Long Laboratories, may be had on request. The data also lists information requirements for obtaining recommendations on specific applications of this and other types of oil coolers.

Write to Dept. OC 1, Long Manufacturing Division, Borg-Warner Corp., 12501 Dequindre Street, Detroit 12, Michigan. In Canada: Long Manufacturing Company Limited, Oakville, Ontario. Export Sales: Borg-Warner International, 36 South Wabash Street, Chicago 3, Illinois.



Formsprag Full-Complement Over-running Clutches eliminate artificial spacing and built-in drag

In automotive, aircraft, truck and farm implement power transmission applications — designers are exceedingly aware of the need for increased torque capacity in less space.

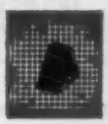
Formsprag Clutches provide a positive solution. The backbone of these over-running clutches is the exclusive, highly-developed sprag. Due to their construction, a full-complement of sprags can be fitted into a given space . . . *and they space automatically.* The result: Greater engine torque capacity is transmitted and the unit is compact.

In addition, no built-in drag is required. The consequent wear is eliminated and you are guaranteed of much longer clutch life.

As the pioneer in the manufacture of sprag clutches, Formsprag offers the finest in precision manufacture and design facilities. Simple, basic design makes them ideal for economical prototypes for testing. *Complete* clutches are a specialty.

"Need Compact Torque Capacity?" Call on Formsprag—World's largest exclusive manufacturer of over-running clutches.

FORMSPRAG COMPANY



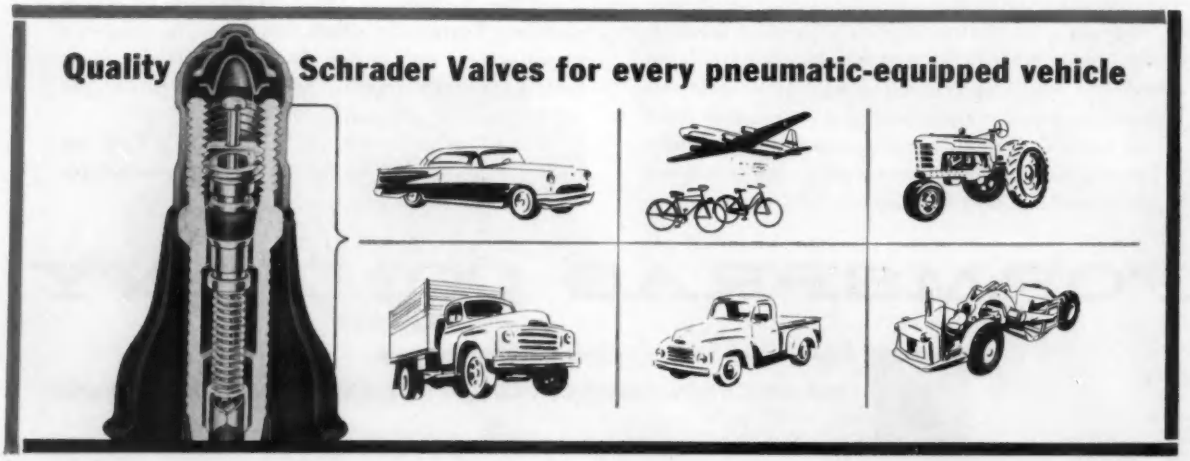
23585 HOOVER ROAD, VAN DYKE (DETROIT), MICHIGAN

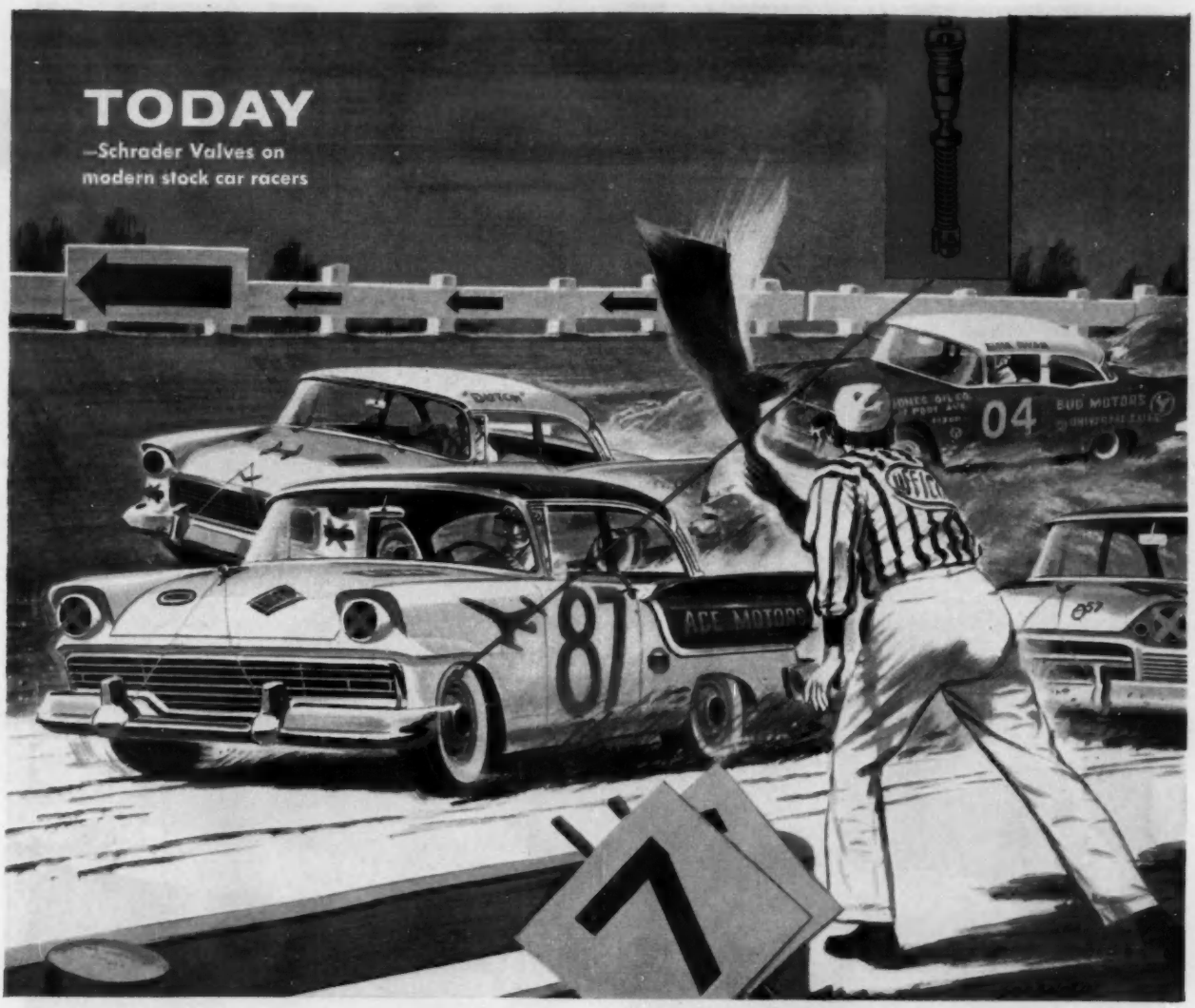
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The combined experience of the Automotive, Tire and Tire Valve Industries has made possible extremely high standards of performance. Schrader puts all this experience together to design and produce the most dependable tire valves for every type of vehicle in use today or planned for the future. You can count on quality Schrader Tire Valves to match the performance of your vehicles.

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FOR ORIGINAL EQUIPMENT AND REPLACEMENT

AN EXAMPLE OF DESIGN



FOLLOW-THROUGH AT CHANCE VOUGHT

Integral Tanks in a *Razor-Thin* Wing

How to make a fuel container out of a supersonic wing . . . Crusader designers who were given this problem saw in it the earmarks of a typical Chance Vought assignment. First, the job had never been done before. Second, the whole problem was theirs to solve and control — from design through test to the factory floor.

They began with a philosophy that proved sound all the way: design a fuel container first, then make it behave like a wing. Next, they focused on the major problem — adequate sealing — and selected a sealing method to solve it.

To determine best configurations and leakproof bolt and screw attachments, designers put several trial tanks through a stiff test spectrum. Then they moved to the shop to oversee the production and assembly of parts for their wing.

Looking ahead to the assembly line, they prepared a manual for shopmen and held classes explaining methods for assembling and sealing the two-purpose wing. To complete their job, they also wrote a maintenance bible on wing tank repair — a book which, significantly, hasn't been needed to date.

Technically, the fuel cell project was one of a kind. So was our pioneering work in electromechanical stabilization systems. Likewise, our discoveries in antenna weight, cost and performance improvement resulted from specialized effort.

In engineering challenge, however, these efforts were related. Each allowed the designer to take a new route . . . to follow through . . . and to see his idea make good.

Fluid and Propulsion Test Engineer. To work on central system simulators and fuel, hydraulic and pneumatic systems and components. Engineering degree and three years related experience required.

Components and Standards Engineer. To develop, evaluate and standardize a variety of aircraft functional components. Requires engineering degree and two years related experience.

4 IMMEDIATE OPENINGS FOR ENGINEERS

Support Equipment Designer. To design shipboard handling equipment and loading devices for missiles and fighter aircraft. Requires flair for mechanical design, an engineering degree, or equivalent experience.

Power Plant Installation Designer. To design fuel, air induction and accessory systems, and engine mountings. Requires engineering degree, or equivalent, and ability to prepare specs, layouts and detail drawings.



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You pay neither sales tax nor city and state income tax in Dallas. Living costs are low, and top recreation is close at hand. You can use these savings as Dallasites do — on outdoor fun for the family.

For a firsthand look at our engineering opportunities, arrange now for a personal interview at Chance Vought. Or, for a report on our openings, write to:

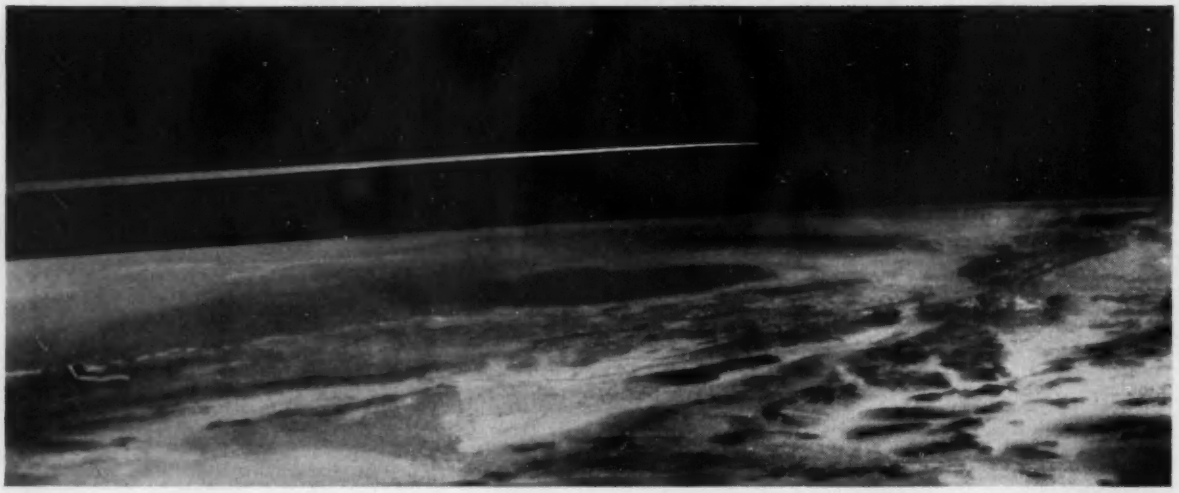
Mr. J. W. Larson, Asst. Chief Engineer,
Dept. SAE-3

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.



Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity – and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho – and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.



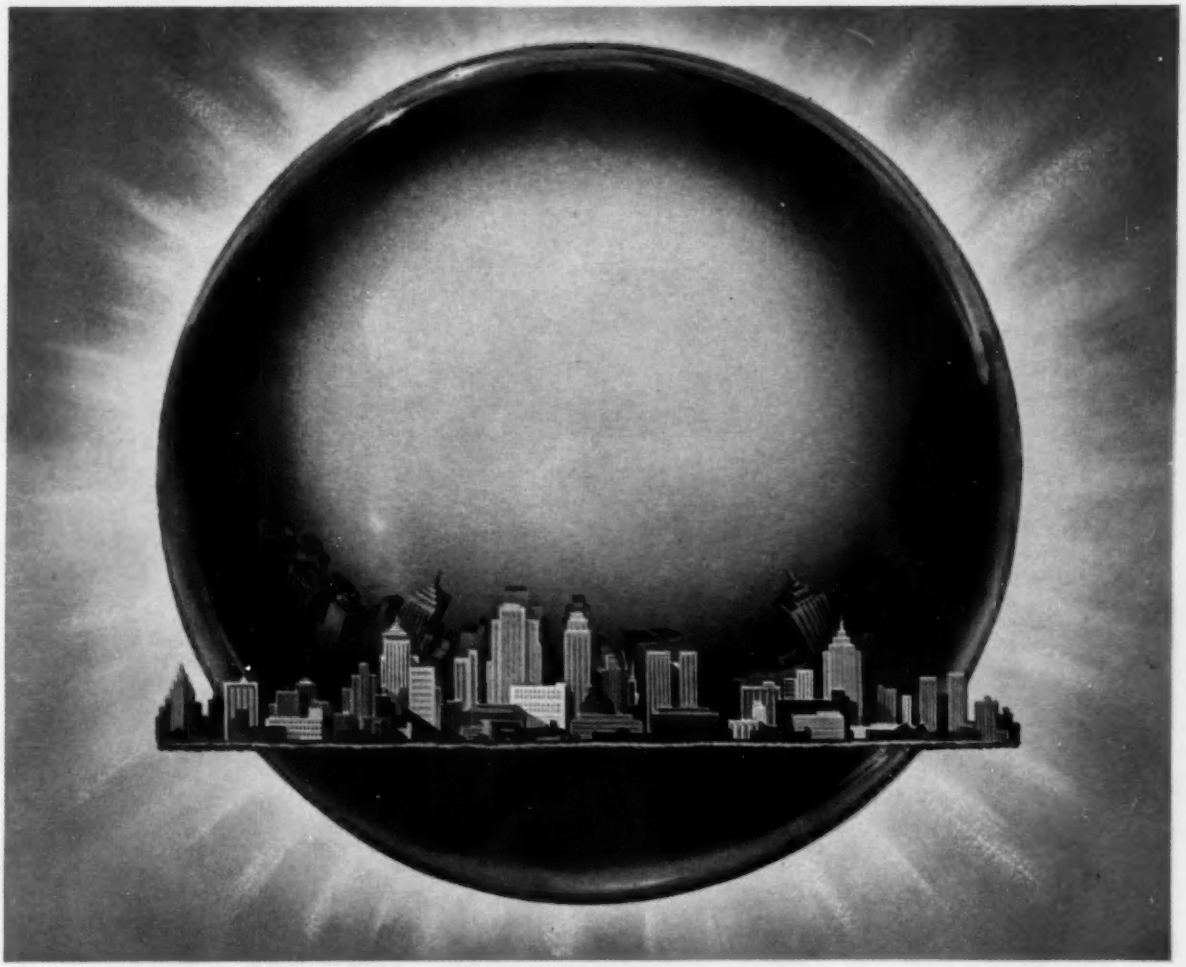
LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-SAE-4.
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.



Imagine a mile-wide ball with surface finish accurate to within 1/16"

If Hoover could make this giant bearing ball—one mile in diameter—and maintain Hoover quality of precision manufacture, the immense sphere would be so smooth that surface finish would be accurate to within 1/16 inch!

In actual terms, the surface smoothness of a Hoover Ball is measured on a micro-inch basis. Roundness and diameter are held within 25 millionths of an inch. Microscopic precision, both in smoothness and spherical accuracy, means quality in Hoover *Micro-Velvet* Lapped Balls.

Equipment which will measure surface quality to a fraction of one millionth of an inch is used to check and re-check Hoover Balls. A perfectly matched set of *Micro-Velvet* Balls goes in each bearing.

These precision-made balls team up with the ultra-smoothness and minutely exact curvature perfection of famous *Hoover Honed* Raceways.

The result . . . equalized load, high capacity, and quiet operation, assuring superior operating performance and long life.

Investigate Hoover's complete line of balls, made in many metals, as well as light, medium and heavy series ball bearings. Engineering assistance is readily available to manufacturers. Write for information.

HOOVER HINTS:

Factors Involved In Bearing Selection

Application is the key to bearing selection. The importance of a bearing's characteristics is relative to the job it must do. Usually one of the most important factors is the capacity or load-carrying ability. Also important in many applications is the type of loading—thrust, radial or combined . . . the amount of friction involved . . . the ease of assembling a bearing into a unit . . . the danger of misalignment . . . the limiting maximum speed.

All types of anti-friction bearings are concisely compared and analyzed from an engineer's standpoint in "Engineer's Handi-Book of Anti-Friction Bearings." Send for yours now.



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9

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Lightweight! But magnesium can really take punishment

Magnesium is the world's lightest structural metal. It weighs only 23% as much as steel, 20% as much as yellow brass and 65% as much as aluminum. But magnesium is strong, too. How strong? Look at a few of its uses in the aircraft industry, for example:

The magnesium wheel in the picture above has to be light, but it also has to withstand tremendous shock when the plane touches down. In another application, the entire weight of a two-ton helicopter is suspended from a magnesium rotor. In large cargo planes magnesium floor members support heavy weights in flight.

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What do these facts mean in terms of your products, parts or equipment? They mean that magnesium can do an equal or better structural job at a substantial savings in weight. For more information, contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department MA 1401D.

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REDUCE CRANKSHAFT VIBRATION

. . . in Diesel Engines



with a HOUDAILLE TORSIONAL VIBRATION DAMPER



A Inertia mass or flywheel
B High viscosity synthetic fluid
C Hermetically sealed housing

THE SHEARING ACTION of highly viscous fluid, used exclusively in the Houdaille damper, makes it the *most practical, most efficient* method of reducing torsional vibration in diesel engine crankshafts. A true damper and not a detuning device, it is effective across the full range of engine criticals. To diesel and gasoline engine manufacturers, it offers greater horsepower and speed . . . to diesel engine users it means smoother operation, longer life and less maintenance.

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EXPERIENCED ENGINEERS

and precision production facilities at Houdaille are at your service for any application involving hydraulics. Write Department SAE for specifications and performance data on Torsional Vibration Dampers, Rotary Shock Absorbers or Friction Snubbers



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BUFFALO HYDRAULICS DIVISION

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not one of these 8 technical men at RMI started his career in Rocketry!



Assistant Project Engineer. B.S. Chemical Engineering



Preliminary Design Group Leader. B. Aero Engineering. M. Aero Engineering



Senior Engineer. B. Mechanical Engineering



Research Physicist. B.S. Physics & Math. M.S. Physics



Design Engineer Group Leader. B.S. Industrial Engineering



Instrumentation Engineer Group Leader. B.S. Electrical Engineering



Senior Stress Engineer Group Leader. B.S. Civil Engineering. M.S. Applied Mechanics



Senior Research Chemist. A.B. Chemistry. A.M., Ph.D. Organic Chemistry

Let these 8 men who switched to Reaction Motors help you score Your Success Potential in Rocketry

RMI Task Force Has Prepared A Technical Test You Can Take At Home

Many engineers and scientists today are turning interested eyes toward the expanding field of Rocketry, aware that this young giant among American industries offers unsurpassed opportunities for the future.

Naturally, they are wondering whether their backgrounds fit them for this demanding field.

Now Reaction Motors — in cooperation with professional men who have made the transition from other fields successfully — has devised a way for you to determine *in advance* your likelihood for success in Rocketry. They have prepared a purely *technical test* which you can not only take at home, but evaluate for yourself. A sealed envelope containing the correct answers comes with the Question Sheets.

Reaction Motors has *two* reasons for offering you this unusual service:

1. We need more highly skilled, very creative professional men with varied experience to meet the current great expansion in rocket development projects here.
2. We want to reduce to the absolute minimum the possibility of your making the wrong career decision. We believe that every man who enters a field should have reasonable assurance of staying with the field and achieving outstanding success.

Here is your opportunity to discover — quickly and easily — whether Rocketry, with its literally unlimited objectives, is for you.

Note: There is one Question Sheet for *Mechanical Engineers*, another for *Aerodynamicists*, a third for *Chemical Engineers*, etc. So please check your field in the coupon below, to ensure receiving the Test that applies most directly to you.

FILL OUT AND MAIL THIS COUPON FOR RMI'S SELF-EVALUATING TECHNICAL TEST OF ROCKET ENGINEERING POTENTIAL



Take this test yourself in the privacy of your home.

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ATT: 8 Man Task Force

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Please send me your Self-Evaluating TECHNICAL TEST for Success Potential in Rocketry

*My Name*_____

*My Address*_____

Please check your field.

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- ☐ Elect. Engineering
- ☐ Chemical Engineering
- ☐ Civil Engineering
- ☐ Aeronautical Engineering
- ☐ Industrial Engineering
- ☐ Physics
- ☐ Chemistry

REACTION MOTORS, INC.
"Where today's pioneers cross tomorrow's frontiers"

A copy for every designer

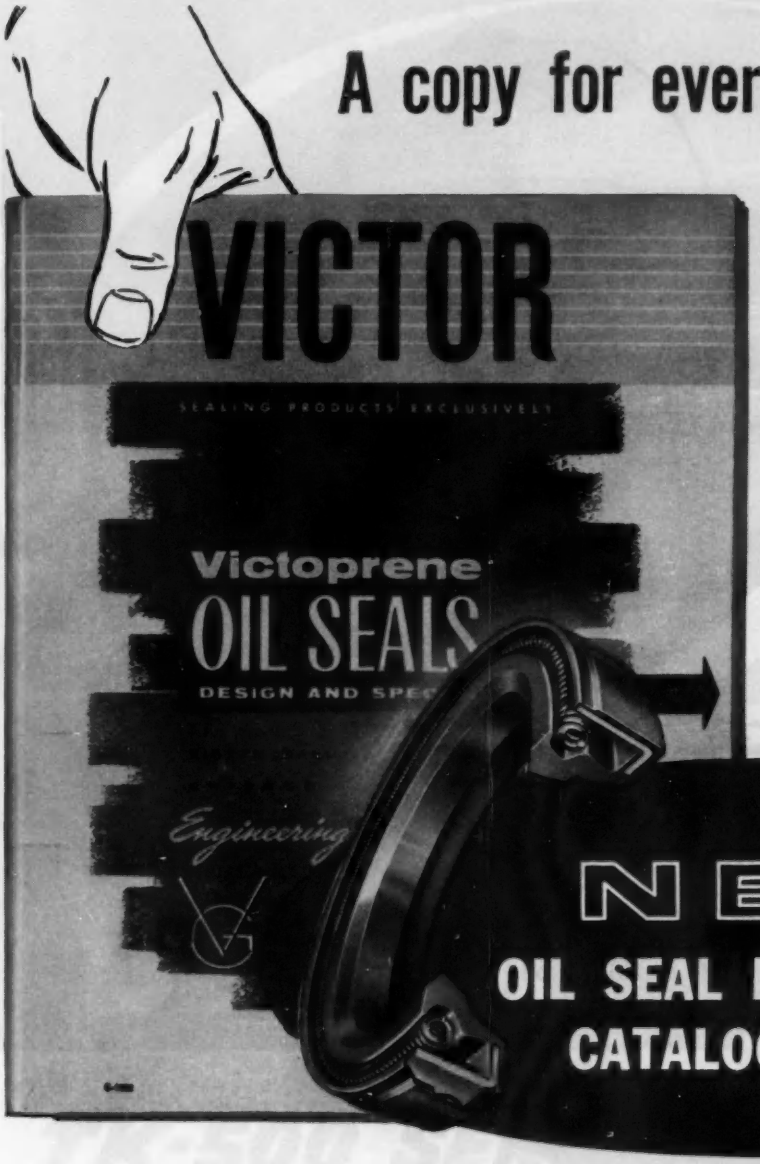


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Seal Sizes and Types—by Numerical Listing
Metal-Encased Felt Seal Listing

Compiled Entirely to Serve Specifier's Needs

You'll quickly see this is not just the usual reference catalog that tells you what you can have. Instead, this new, modern edition shows and tells you how to get the oil seal you need —and how to insure effective performance.

60-page working guide

Here you will find all essential data for modern oil seal specification procedure—much of it in useful form for the first time in any catalog. Every section in the contents table offers valuable help toward better shaft sealing.

Note 2 outstanding features:

All sizes and types of Victor designs are grouped by shaft diameter—the primary consideration. A cross section of each design is immediately adjacent for quick reference.

Specific recommendations are given on design adaptability in relation to pressure, temperature, and shaft speed conditions.

Your copy sent on request

The more you use this catalog, the more you will be impressed with the fact of Victor's pre-eminence in the quality oil seal field, both in meeting your standard as well as custom requirements.

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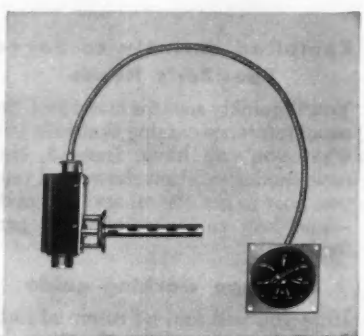


S.S.White

Flexible Shafts Withstand Temperature Extremes!

A leading aircraft manufacturer has used S.S. WHITE flexible shafts for many years to transmit control between this graduated dial and aircraft thermostat. He finds that under any kind of temperature conditions, there is no measurable variation in torque to turn the shaft, or in torsional deflection required to initiate cam movement over the temperature range!

This ability to withstand temperature extremes is only one of the many remote control and power drive advantages industry has discovered in S.S. WHITE flexible shafts. Perhaps they can help you to simplify control or product design . . . cut your production costs . . . speed assembly. These quality shafts range from small to large sizes, and up to 12 feet in length. The assistance of our engineering staff in helping you work out a flexible shaft application for your product is yours for the asking. Just write to



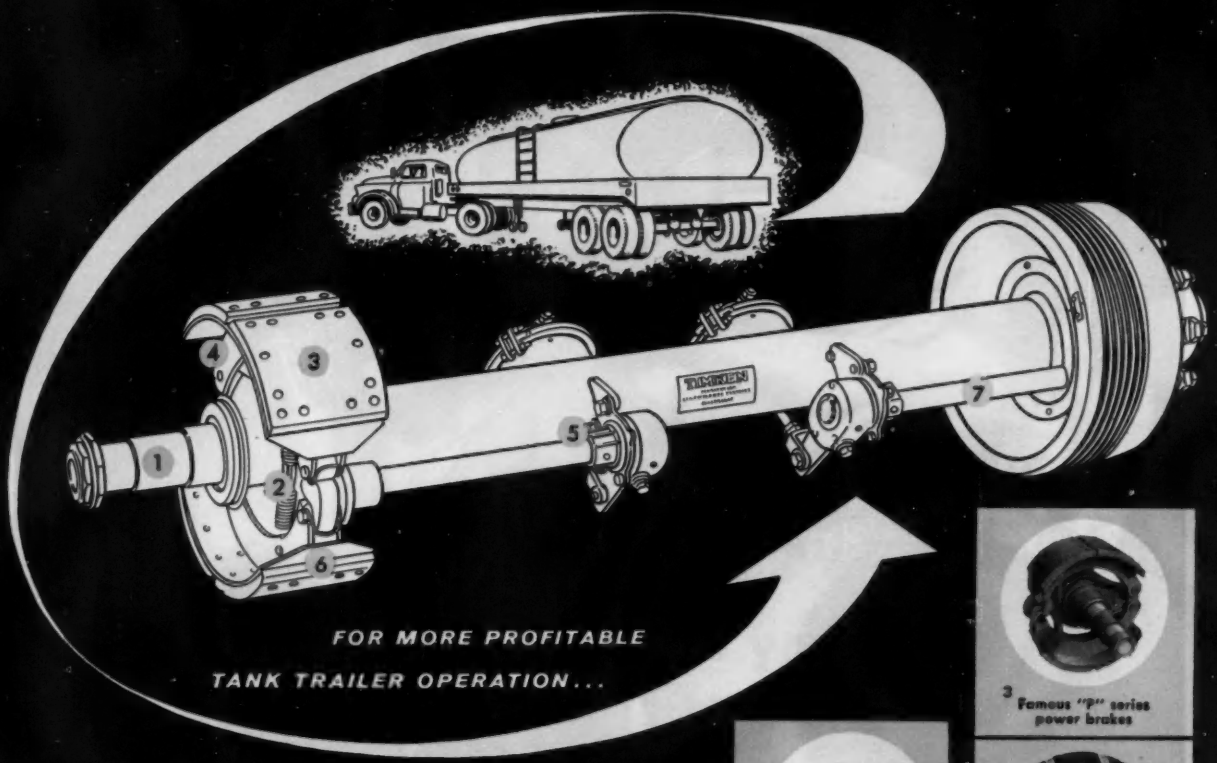
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FIRST NAME IN FLEXIBLE SHAFTS



USEFUL DATA on how to select and apply flexible shafts. Write for Bulletin 5601.

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1 Load-proportioned hot-pierced spindles

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2 Free rotating brake shoe rollers


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TRAILER AXLES!

Get up to 140 lbs. of extra payload every trip . . . plus a full range of sizes in "P" series brakes!

Timken® advanced design and engineering features make the new TK-500 Series Trailer Axles your ideal choice for more economical, more dependable tank trailer operation. Lightest for their capacity ever built, the new TK-500 Axles give you more payload capacity every trip—with no reduction in either strength or quality.

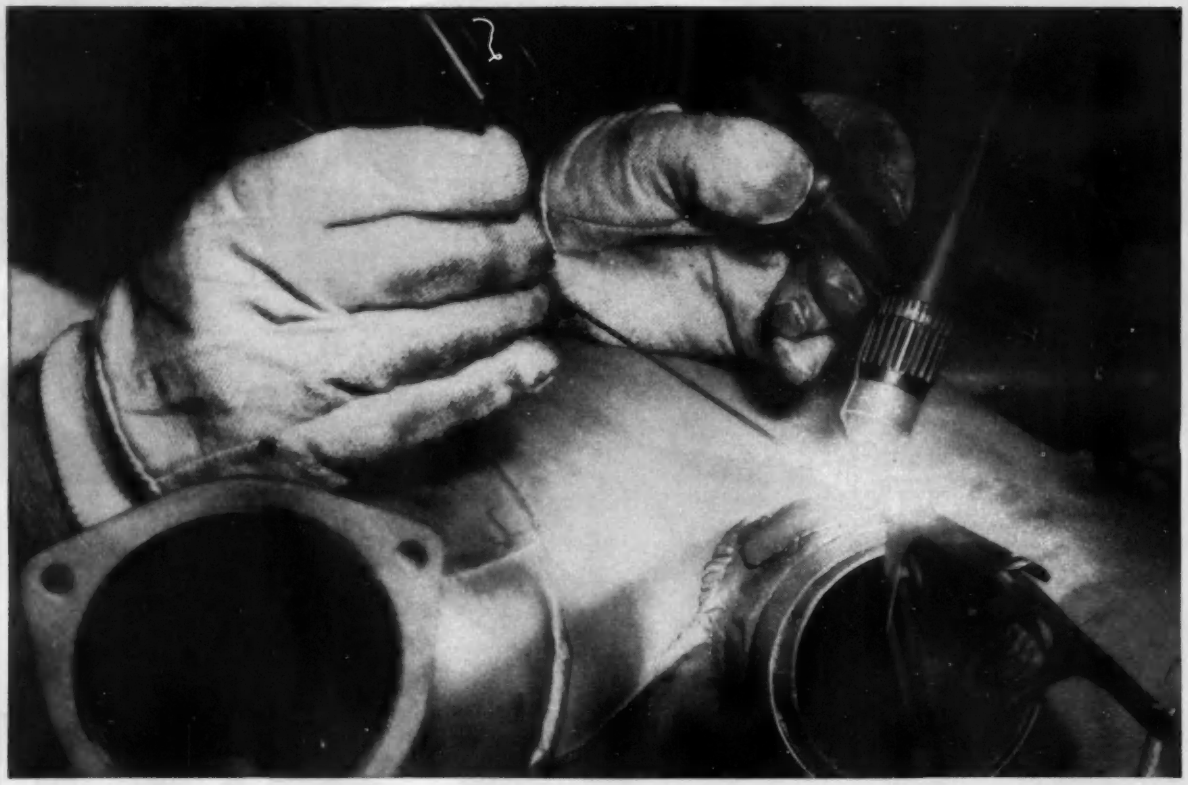
TK-500 Axles are equipped with TDA® "P" Series Brakes, which are now available in a complete range of sizes...6", 7", 8½" and 10". All are 16½" in diameter.

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ROCKWELL SPRING AND AXLE COMPANY
Accepted TDA Standard

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WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS



It took only 10 min. to repair this aircraft manifold by HELIARC welding—the savings amounted to $1,485 over the price of a new manifold.

"HELIARC" WELDING SAVES 99%

Of New Part Cost...

Throughout industry, HELIARC welding is being used to make repair welds in all types of commercially fabricated metals—at a fraction of new part cost. In the repair operation shown here, a ⅛-in. thick stainless steel aircraft engine exhaust manifold was HELIARC welded and made good as new for $15... the cost for a new manifold would have been $1,500.

Whether used for fabricating or repairing, HELIARC welding is ideal for joining light gage metals. Welding can be done in all positions on all types of joints—with portable manual, and semi-automatic equipment. Mechanized setups are also available.

In HELIARC welding there is no slag, spatter, or smoke. The weld area is argon-gas-shielded from the harmful effects of the atmosphere, and the operator can see and control the weld puddle at all times.

HELIARC welding may be the answer to *your* fabricating and repair problems. Find out—call or write your local LINDE Representative today.

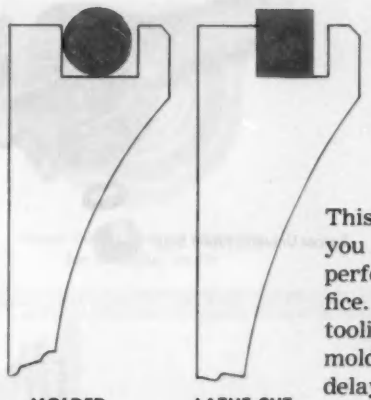
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Division of Union Carbide Canada Limited, Toronto

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Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



MOLDED O-RING SEAL

LATHE-CUT SEAL

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There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

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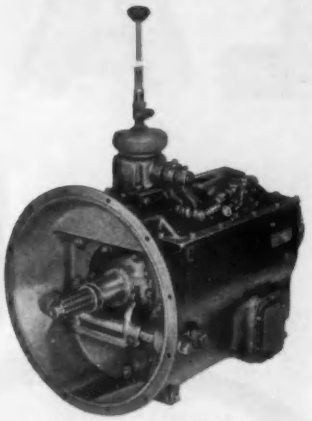
Branch Offices — LOOK in the "Yellow Pages" — in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

How many of these

NEW SPICER

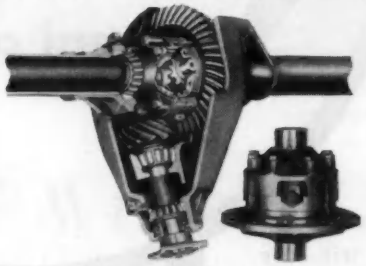
can you use?



Spicer Air-Assist Shift for Spicer Synchronized Transmissions



Spicer Heavy-Duty Clutch



Spicer POWR-LOK Differential Unit and Spicer Axle with POWR-LOK Differential



Spicer Universal Joint Seal

THESE are new and recently-announced Spicer units . . . each one evidence of the ingenuity of Dana engineers in meeting today's fast-changing needs in power transmission!

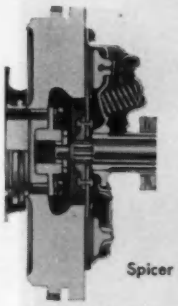
Creative ability, and the talent for putting *action* into thoughts and plans, come naturally to the Dana engineering staff.

Since 1904, they have worked hand in hand with the manufacturers of every type of automotive vehicle . . . employing every type of power . . . and using every power transmission principle.

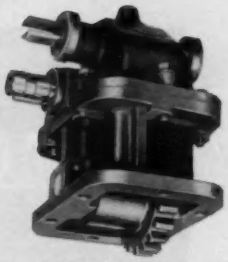
The complete line of Spicer products . . . produced by skilled personnel in 10 great and modern Dana plants . . . can serve you fully, completely, dependably!

DANA CORPORATION, Toledo 1, Ohio

PRODUCTS



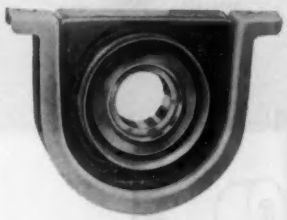
Spicer Split-Torque Clutch



Spicer Model FA Power Take-Off



Spicer Telescoping Propeller Shaft Assembly



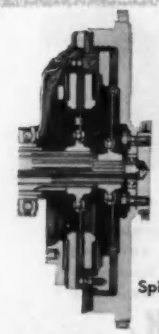
Spicer Center Bearing Mounting for Propeller Shafts



Spicer 1480 Series Universal Joint



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Spicer Two-Stage Tractor Clutch



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NEW

Tachometer Take-Off



...for VEEDER-ROOT Rev-Counters

With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:

Everyone... Can Count on

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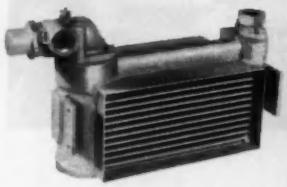
COOL COMMANDER!



Harrison Cools Aero Design's Ultra-Modern Executive Transport!

New ideas in the sky . . . a new concept in airway travel! That's what this sleek, ultra-modern Aero Commander represents. It's fleet, maneuverable, comfortable . . . the ideal way to get there and *get there fast* for the modern business man. And it's Harrison that gets the cooling call on this popular new executive transport. Beating the heat for the most advanced aircraft is a Harrison specialty. It requires engineering skill, production know-how and the research facilities that you'll only find at Harrison. So remember . . . if you have a cooling problem, look to Harrison for the answer.

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N. Y.



Lightweight, heavy-duty Harrison oil cooler is in command of heat on the advanced Aero Commander.

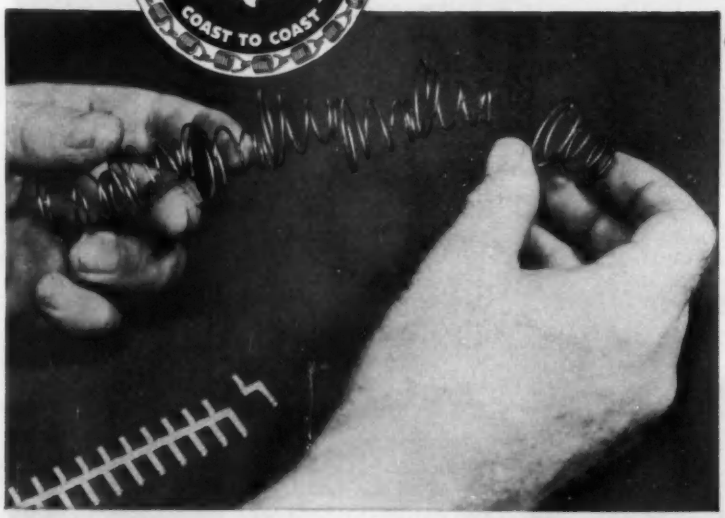
GM GENERAL MOTORS

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TEMPERATURES MADE TO ORDER

HARRISON

How Creative Spring Engineering Aids Automation...

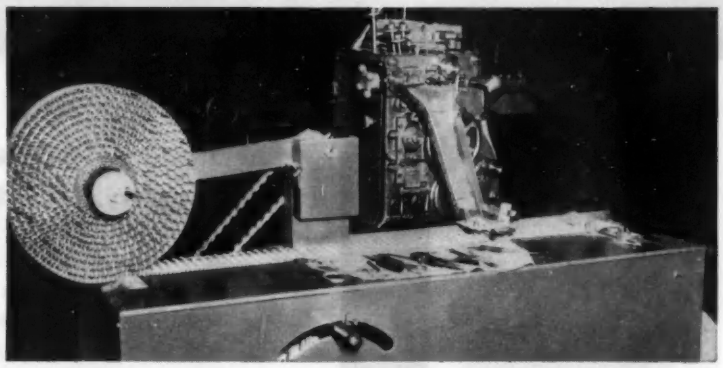


"Designed Deliveries"

engineered by Divisions of Associated Spring Corporation can be time and money savers for spring users.

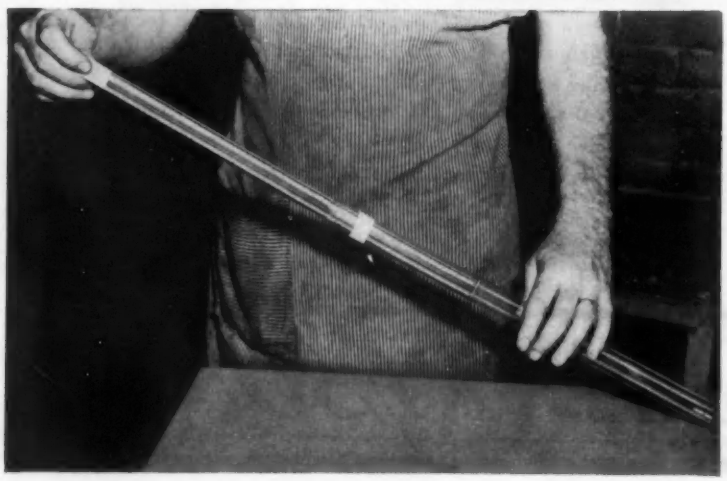
Continuous coiled springs are notched at intervals—individual units broken off as needed. (Where precision ends are not required.) *Lower left corner:* Small terminal plugs supplied in strips, also notched for ease in use at assembly line.

Small open coiled springs fed from coiler into valleys of corrugated board strip. Roll at left is ready to ship—springs arrive safely—untangled.



5705

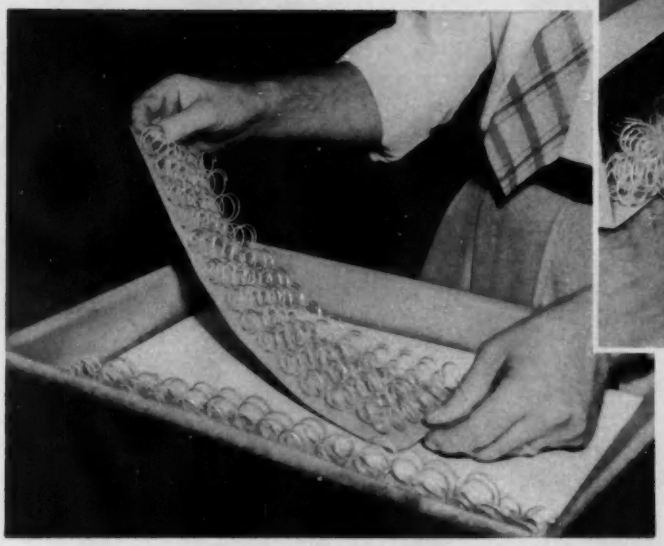
© 1957 ASSOCIATED SPRING CORPORATION
BRISTOL, CONN., U.S.A.

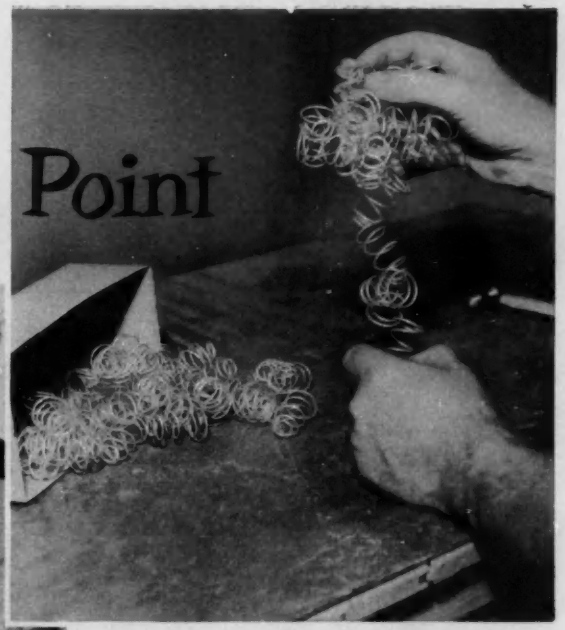


Delicate wire heater elements are caught on a flat steel strip from machine—inserted in plastic tube which protects from distortion and atmosphere. Ready for automatic feeder in customer's assembly setup.

Divisions of

at the Assembly Point





Before-and-after views show tangle of springs in bulk shipment—and same springs held on layers of pressure-sensitive tape ready for instant selection.

Tiny hairsprings for precision electrical meters are nestled in recessed pads, avoiding distortion from contact in shipment or storage at point of use.



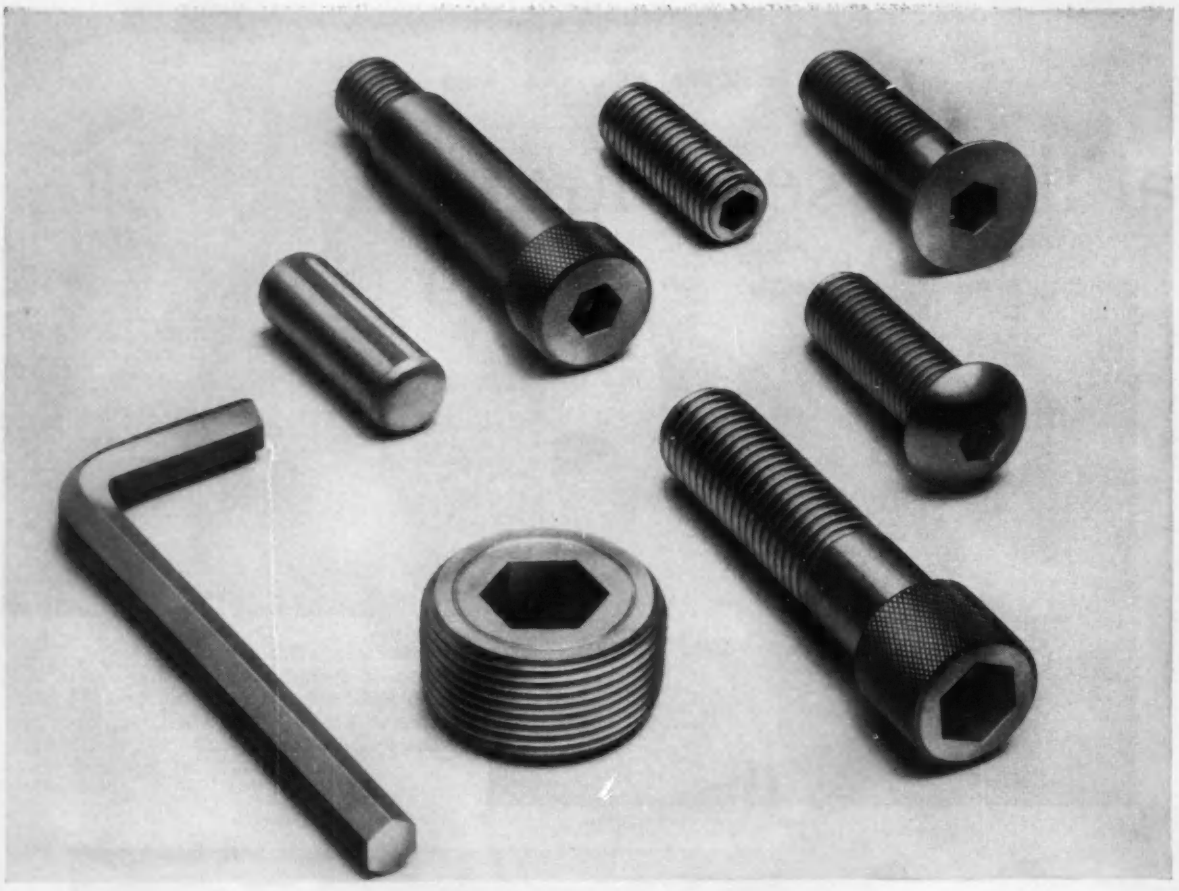
Do these examples suggest an approach to your spring problem? Write for pamphlet "M T M," giving further information.

DIVISIONS OF ASSOCIATED SPRING CORPORATION
COAST TO COAST

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WALLACE BARNES COMPANY, STATE FAIR BLVD. SYRACUSE 9 (Solvay), N.Y.
MILWAUKEE DIVISION, 341 E. ERIE ST. MILWAUKEE, WIS.
DUNBAR BROTHERS COMPANY, BRISTOL, CONN.
F. H. MANROSS AND SONS CO., BRISTOL CONNECTICUT
THE WALLACE BARNES CO., LTD., HAMILTON CANADA

ASSOCIATED SPRING CORPORATION

GENERAL OFFICES: BRISTOL, CONNECTICUT



Now – Cleveland provides a single source for all your socket screw requirements

Simplifies specification, cuts paper work, speeds delivery

CLEVELAND STANDARD SOCKET SCREW PRODUCTS
UNIFIED THREADS—CLASS 3A FIT

Type	Standard Sizes (diam.)	Material
Socket head cap screws	#0 to 1½ in. (larger sizes avail.)	Alloy steel, heat treated or Nonmagnetic 18-8 stainless
Set screws (cup, half dog, flat, cone or oval points)	#0 to 1 in. (#0-#3, cup point only)	Alloy steel, heat treated or Nonmagnetic 18-8 stainless (to ½ in., cup point only)
Flat head socket cap screws	#4 to ¼ in.	Alloy steel heat treated
Button head socket cap screws	#4 to ⅜ in.	same
Shoulder screws (stripper bolts)	¼ to ¼ in.	same
Dowel pins	⅛ to 1 in. (nominal size and .001 in. oversize for repair)	same
Pressure plugs	⅛ to 1¼ in. NPTF	same
Socket screw keys	.028 to 1 in. across flats; short or long arm	same

Cleveland has expanded its socket screw line to provide a single source for all your socket head needs.

At the same time, and in conjunction with opening its new plant, Cleveland is doubling its factory warehousing capacity. This, plus the latest materials handling equipment, will enable Cleveland distributors to get same-day shipment of your larger orders.

Included in the expanded Cleveland socket screw line are precision dowel pins. While not a socket head product, they are basic fasteners for the important tool and die industry, where they are closely associated with socket head cap screws and shoulder screws. We offer them as part of a complete service.

Cleveland socket head cap screws are upset forged from heat-treated alloy steel. This results in symmetrical, unbroken grain structure in heads, threads and fillets—greater fatigue and tensile strength, stronger fasteners.

Write for latest literature and technical data. Then see your local Cleveland Cap Screw distributor for all your socket screw requirements.

THE CLEVELAND CAP SCREW COMPANY
4444-12 Lee Road, Cleveland 28, Ohio

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern trucking

Stainless steel sets new standards of performance for truck trailers. Experience proves that stainless outlasts and outwears other materials and is always easier to maintain.

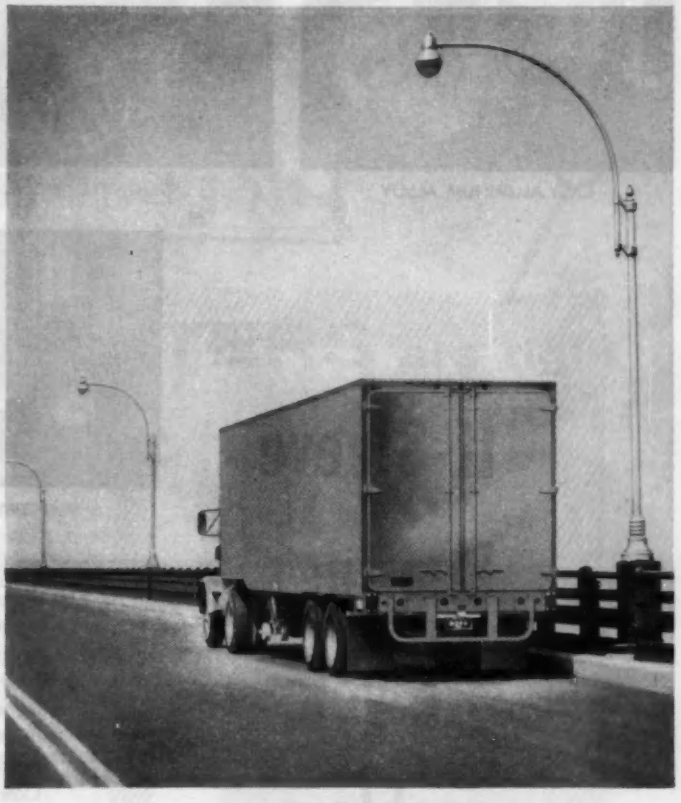
That's because stainless is practically immune to corrosion and rust. Its inherent toughness makes it hard to dent or scratch. Operating costs are less, too, because stainless needs no paint or special finish—the beautiful smooth surface is always quick and easy to clean. Extra strength lets you carry bigger payloads safely. No wonder more and more stainless steel units are going into service each year!

For more information about stainless steel and the many ways it can help improve your automotive products—see your stainless steel supplier or write ELECTROMET... leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steel.

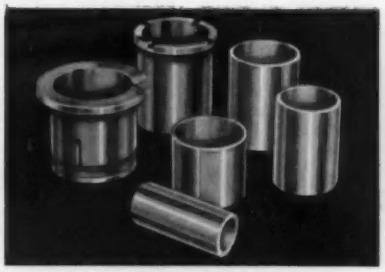
ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N. Y.
In Canada: Electro Metallurgical Company, Division of Union Carbide Canada Limited, Welland, Ontario

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

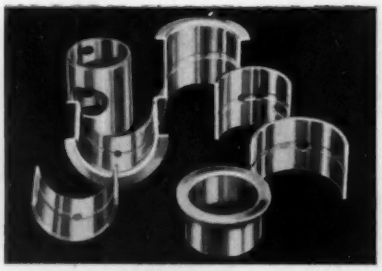
Electromet
Trade-Mark
FERRO-ALLOYS AND METALS



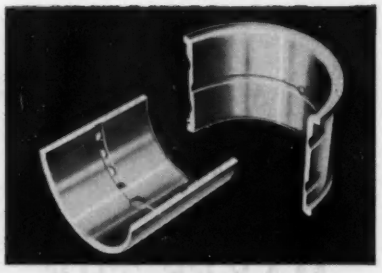
With stainless steel you never compromise on strength, durability or appearance. Stainless makes bigger payloads possible, yet outlasts other materials.



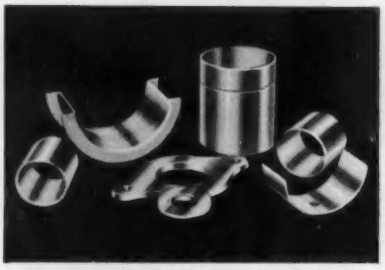
CAST BRONZE



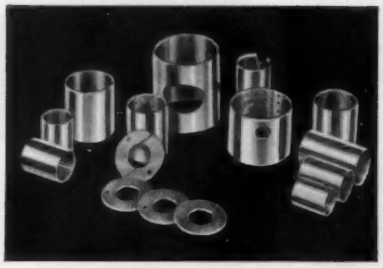
BABBITT AND STEEL



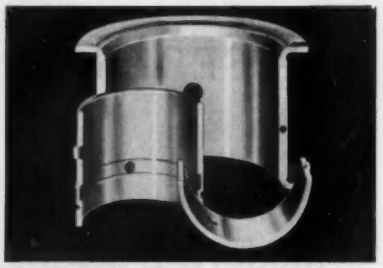
BABBITT AND BRONZE



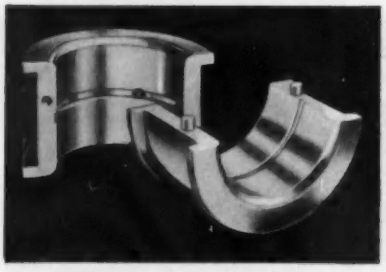
BRONZE OR COPPER-LEAD ON STEEL



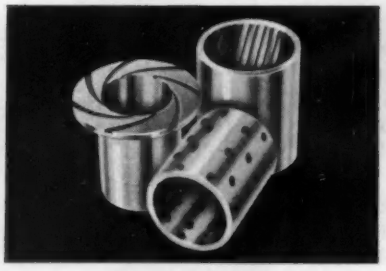
ROLLED BRONZE



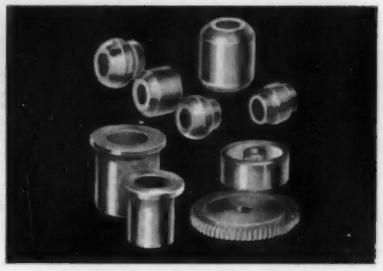
ALUMINUM ON STEEL



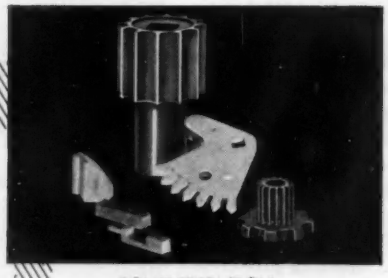
CAST ALUMINUM ALLOY



GRAPHITED BRONZE



LEDALOYL SELF-LUBRICATING



POWDERED IRON

If Sleeve Bearings are your problem...



Johnson Bronze can provide the solution. We produce all types of sleeve bearings in a number of standard sizes. In addition, we have the facilities to produce an infinite variety of custom-made bearings to your specifications. The best bearing for any application can be found among the types illustrated above. To get the exact bearing you need at reasonable cost, contact Johnson Bronze Company, 675 S. Mill Street, New Castle, Pa.

JOHNSON Bearings



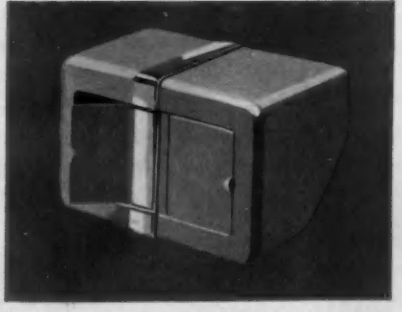
. . . as EVANS HEATERS are right for trucks!

The cowboy's gear is picturesque yet practical. From sombrero to spurs it's designed to help him do a special job. Evans Heaters are designed and engineered to do a special job, too—a truck-heating job—and Evans Heaters are right for trucks because they're built for trucks!

An Evans Truck Heater provides maximum comfort by flooding the cab with a constant stream of well-heated fresh air which keeps the driver warm and alert, the windshield free from ice and snow. The safety factor increases, so you actually get additional "cargo insurance."

The best materials and the best manufacturing methods are combined to produce these rugged Evans units that deliver high-volume heat with a minimum of maintenance. Every unit is backed by a "repair or replace" parts warranty good for a full year or 50,000 miles.

If you have a stubborn heating problem, Evans engineering advice is yours without cost. For this free service, or a complete catalog of Evans Heaters, write Heating and Ventilating Division, Evans Products Company, Department Z-4, Plymouth, Michigan.



EVANS HEATERS ARE RIGHT FOR TRUCKS
BECAUSE THEY'RE BUILT FOR TRUCKS

REGIONAL REPRESENTATIVES: Cleveland, Frank A. Chase Chicago, R. A. Lennox Co., Inc. • Detroit, Chas. F. Murray Sales Co. • Allentown, Pa., P. R. Weidner

EVANS PRODUCTS COMPANY also produces:

railroad loading equipment; bicycles and velocipedes; Evaneer fir plywood; fir lumber; Evanite hardboard and Evanite battery separators.



There is NO SUBSTITUTE for a forging: NO SUBSTITUTE for Wyman-Gordon Experience

There is more to the superiority of the forged crankshaft than just strength.

No other method of fabrication can compare with the forging process for dependability. The uniformity and predictability of physical properties with minimum variance from piece to piece or from one location to another in the same piece is assured to the greatest degree by modern forging practice.

Top automotive engineers agree that the use of a forged crankshaft permits the design of a more compact engine which is a decided advantage when thinking in terms of limited space available and overall engine weight reduction.

As compression ratios increase and engine outputs go up the risk factor must be reduced. Again, the uniformity of quality in the backbone of the engine, the crankshaft, is most essential and made possible only by a forging.

There is NO SUBSTITUTE for a forging and in a forging there is NO SUBSTITUTE for WYMAN-GORDON quality and experience.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS • DETROIT, MICHIGAN

USING

DU PONT ELASTOMERS

neoprene · Hypalon®

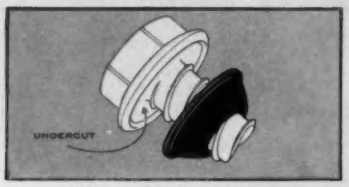


in design

HYPALON protects whitewalls from ozone cracking and discoloration

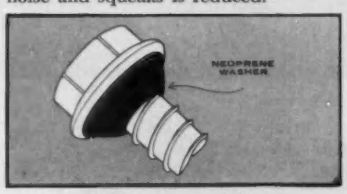
NEOPRENE washers are integral part of leakproof, cushioned fastener

A combination of an undercut head design and a conically shaped neoprene washer gives special advantages to these fasteners.



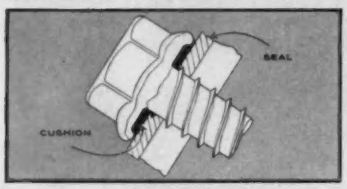
Undercut of fastener head . . .

The washer cushions the head and prevents metal-to-metal contact. Finishes are protected; transmission of vibration noise and squeaks is reduced.



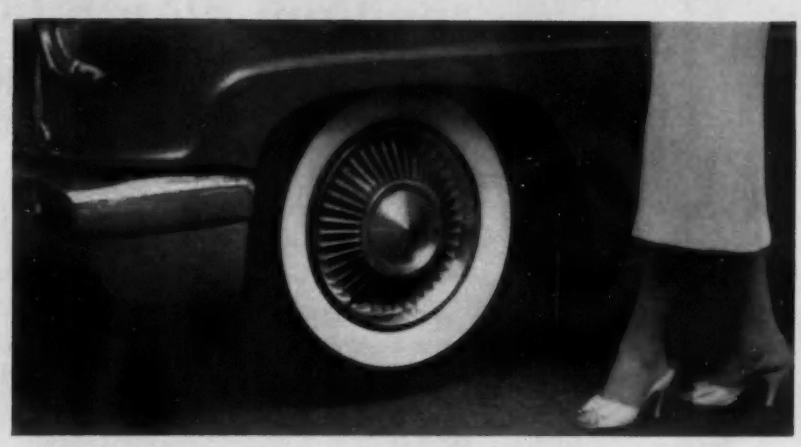
. . . confines and controls flow of conical neoprene washer

As the fastener is secured, the undercut head confines and controls the spread of the resilient neoprene washer, which, in turn, flows into the top threads and seals the fastener hole.



. . . so washer seals the hole and cushions the fastener head.

It's another example of good design made possible with a part made of neoprene—the Du Pont synthetic rubber that is used throughout the automotive industry for resistance to oil, ozone and weather. Just clip the coupon for more information.



Lasting whiteness for sidewalls is assured in areas with ozone concentrations above average

Small amounts of ozone in the air are a primary cause of whitewall deterioration – but a leading tire manufacturer has met this problem by using a special rubber compound containing a substantial amount of HYPALON—Du Pont's new synthetic rubber. Road tests in Los Angeles, where ozone concentrations run higher than average, showed that the whitewalls stayed white and free from cracks through long service periods. These tests have also shown the HYPALON compound to have outstanding resistance to abrasion.

New Design Opportunities

HYPALON's color stability, its outstanding resistance to ozone, elevated temperatures and weather are now being utilized in the automotive field. For example, HYPALON spark plug boots combine immunity to ozone with excellent heat resistance. HYPALON-coated door and window stripping is superior in sunlight and weather resistance. HYPALON-covered ignition wiring shows unusual resistance to hardening at elevated temperatures (250°-350° F.). HYPALON-coated fabric makes colorful, durable convertible topping.

Many possibilities for HYPALON remain for practical application to automotive design. For more information, just clip and mail the coupon below.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



☐ I am particularly interested in _____

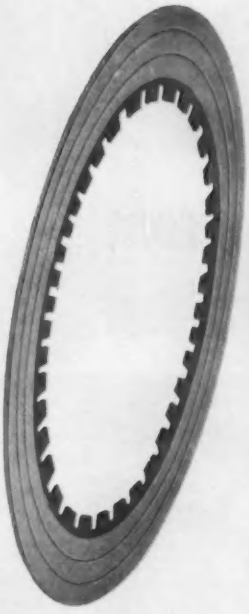
☐ Please add my name to the mailing list for your free publication, "The Du Pont Elastomers."

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E. I. du Pont de Nemours & Co. (Inc.) Firm _____

Elastomer Chemicals Department SAE-4 Address _____

Wilmington 98, Delaware City _____ State _____



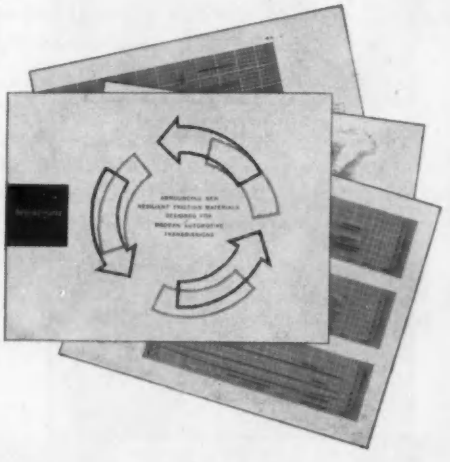
NEW . . . Armstrong resilient clutch facings withstand high pressures, high temperatures

Armstrong now offers a group of resilient friction materials designed to operate under the higher closing pressures, higher temperatures, and faster speeds found in many of today's transmissions.

The compositions are made by an entirely new patented process that combines organic and inorganic fibers with synthetic saturants. They are now operating smoothly in transmissions where closing pressures are up to 400 psi. In some experimental transmissions, the new clutch facings are being used at pressures as high as 2,000 psi.

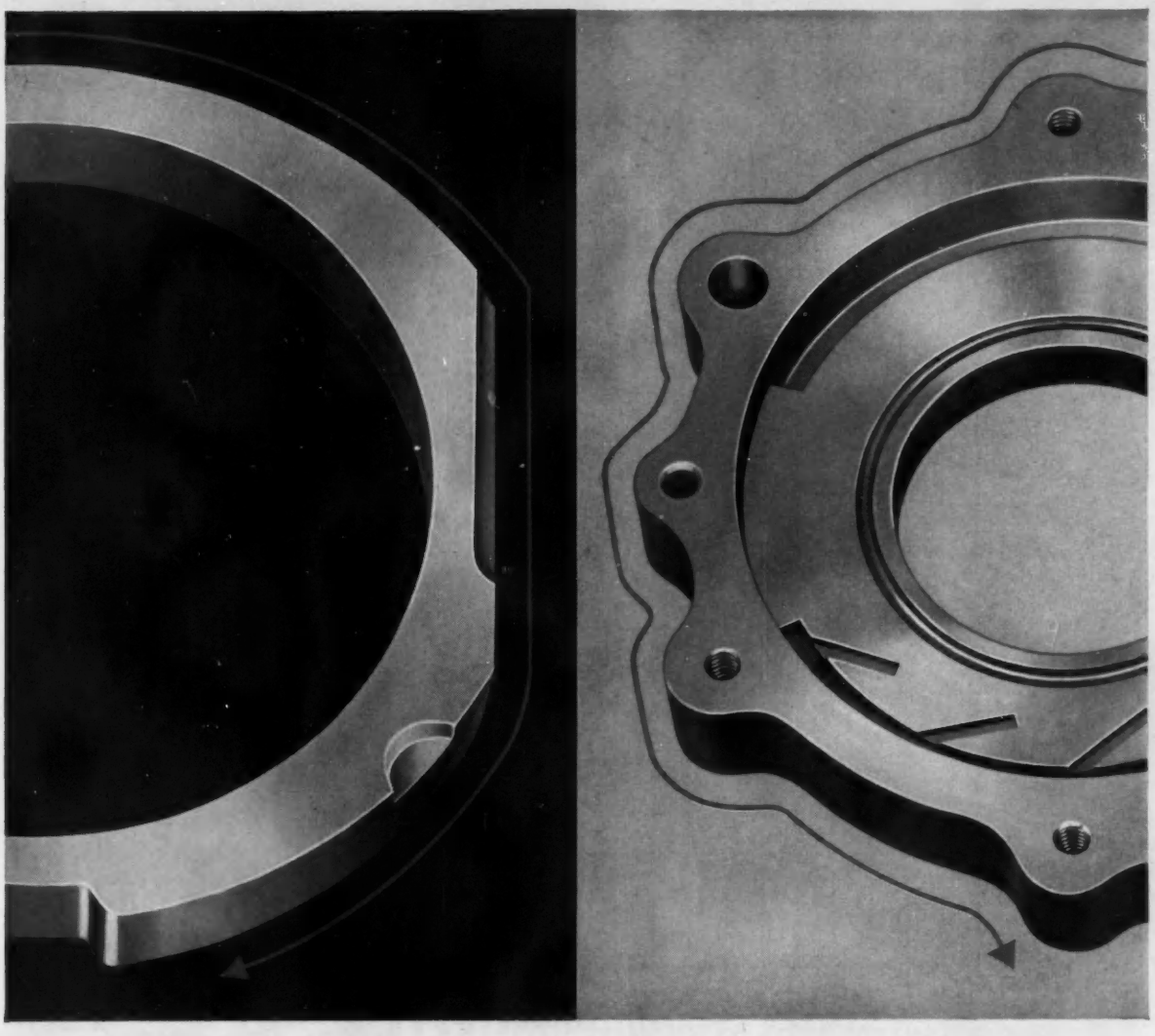
These friction materials have high torque capacity and show virtually no change in coefficient of friction during their long service life. They are designed to run at ambient temperatures in the 250°-315° F. range, and they are not affected by the much higher flash temperatures often encountered under severe engagement.

Send for detailed technical data — including performance curves. It's contained in our new friction materials booklet. Write Armstrong Cork Company, 7204 Durham, Street, Lancaster, Penna.



Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts



Does *complexity* limit use of metal powder?

One shape is simple, the other complex. And while these parts have widely different applications and performance characteristics, *both* were easily produced from metal powder.

Costs were cut because each part could be mass-produced in a single press operation. Yet, closer-than-ever tolerances were maintained.

Moraine Products has the experience gained from the production of hundreds of millions of metal powder parts in an infinite variety of shapes and sizes. This experience and our familiarity with other types of production processes guide our engineers in determining whether our materials and our processes are best suited to the production of a specific part.

When we accept a job to make metal powder parts, it is only after thorough study has shown that the customer will receive parts of the highest uniform quality for dependable end-product performance. Of course, on-time delivery is assured regardless of quantity.

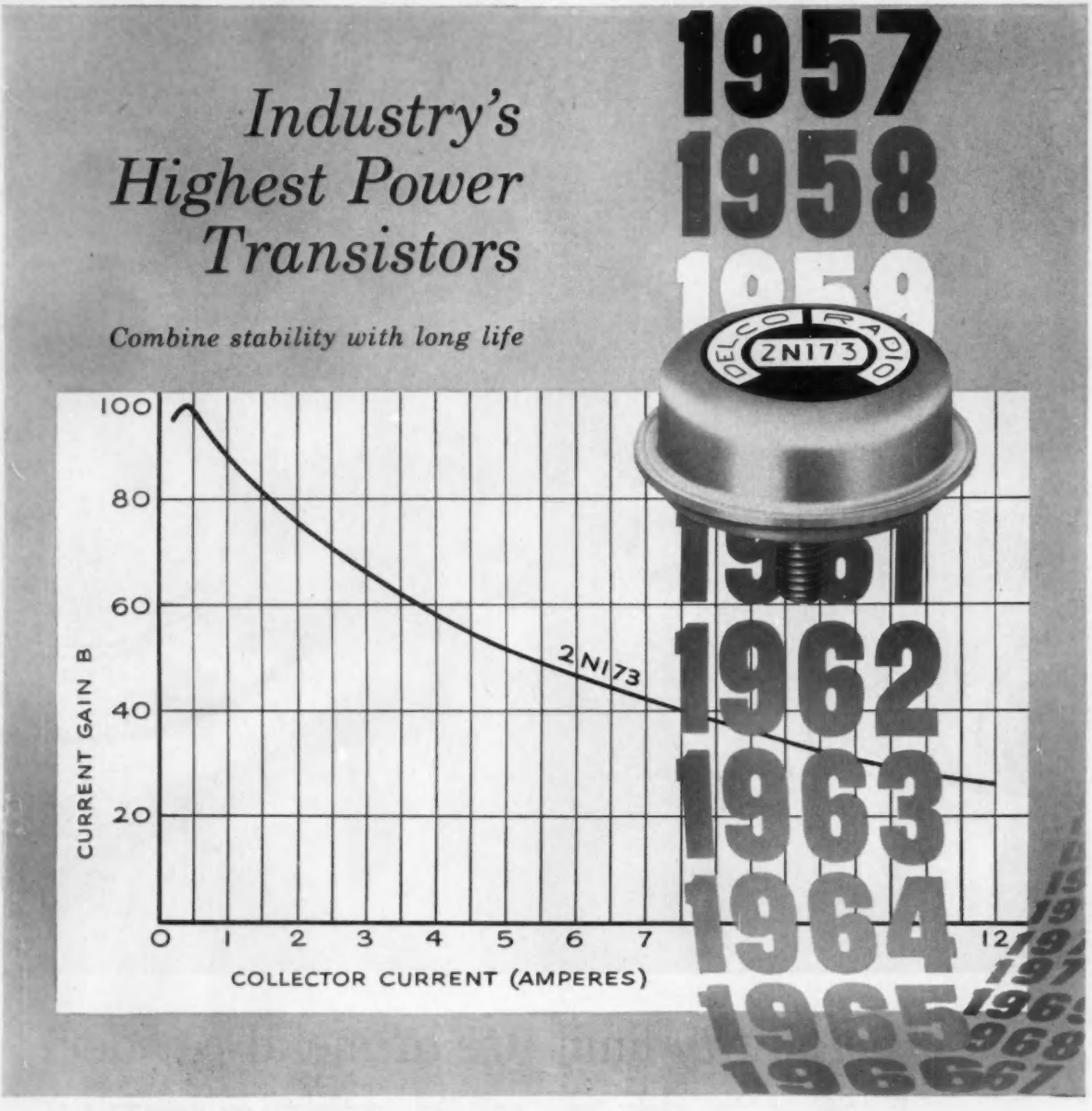
Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

Industry's Highest Power Transistors

Combine stability with long life



Delco Radio's 2N173 and 2N174 alloy junction germanium PNP transistors have unusual stability and reliability. These superior characteristics are retained by hermetic seal and proper internal atmosphere.

In addition, normalizing processes contribute to the high output power, high gain and low distortion characteristics that were designed into them. Delco Radio High Power transistors, ideal for your audio as well as general power applications, are produced by the thousands every day. Write for information and engineering data.

TYPICAL CHARACTERISTICS

	2N173	2N174	2N277
Properties (25°C)	12 Volts	28 Volts	12 Volts
Maximum current	12	12	12 amps
Maximum collector voltage	60	80	40 volts
Saturation voltage (12 amp.)	0.7	0.7	0.7 volts
Power gain (Class A, 10 watts)	38	38	38 db
Alpha cutoff frequency	0.4	0.4	0.4 mc
Power dissipation	55	55	55 watts
Thermal gradient from junction to mounting base	1.2°	1.2°	1.2° °C/watt
Distortion (Class A, 10 watts)	5%	5%	5%

DELCO RADIO DIVISION OF GENERAL MOTORS
KOKOMO, INDIANA



MicroMach extra-high-tensile stainless steel sheets up to 48" WIDE for aircraft and missile use

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

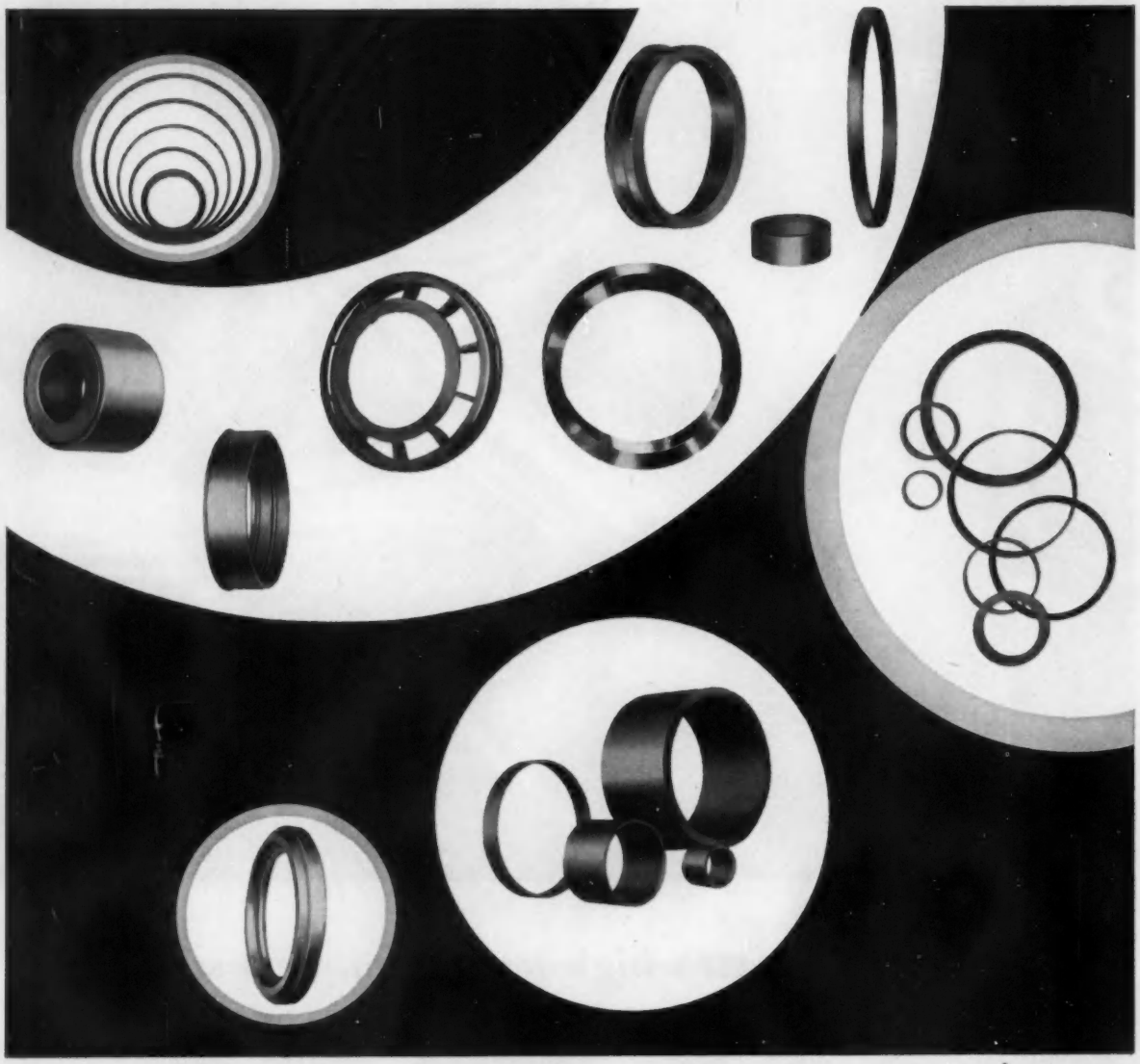
MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

For further information write to Aircraft Steels Dept.

Washington Steel Corporation
4-AA WOODLAND AVENUE
WASHINGTON, PA.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.



IF THE PROBLEM IS CIRCULAR . . . BRING IT TO CLEVE-WELD

If you now use circular parts that are cast or forged, or if you are planning a new circular component, consider the Cleve-Weld Process for three reasons:

1. We can cut your waste costs up to 30% over bulky cast or forged parts.
2. We can eliminate excessive machining by designing sections suitable to your needs.
3. We can, consequently, help you speed your over-all production and cut costs further.

Where expensive alloys and "wonder metals" are involved, we may be able to save you enough in waste and machine time to pay for the finished part.

Our proposition is simple. We have 45 years of design, metallurgical and production experience that can probably save you money. To find out, call, or write and send drawings to: Circular Welded Products Department, Cleveland Welding Company, West 117th Street and Berea Road, Cleveland 11, Ohio.

Another AMF Product

CLEVE-WELD PROCESS

RIMS · RINGS · WELDMENTS

CLEVELAND WELDING DIVISION

AMERICAN MACHINE & FOUNDRY COMPANY

Cleveland 11, Ohio



GET MOVING . . . MAIL THIS COUPON NOW! SAE-704

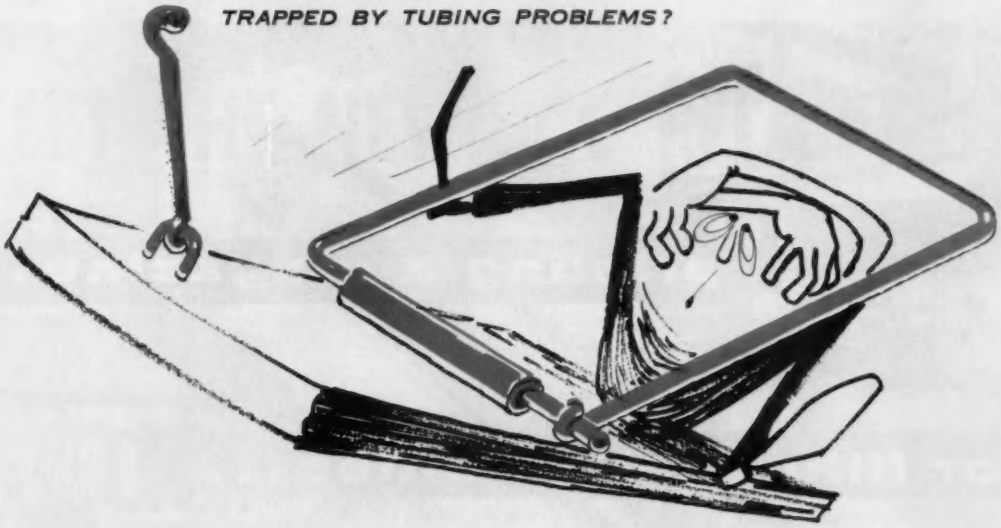
I'd like a brochure on Cleve-Weld's metallurgical, design and production facilities. Particularly, I'd like to know how the Cleve-Weld Process can cut component costs while improving performance.

NAME_____

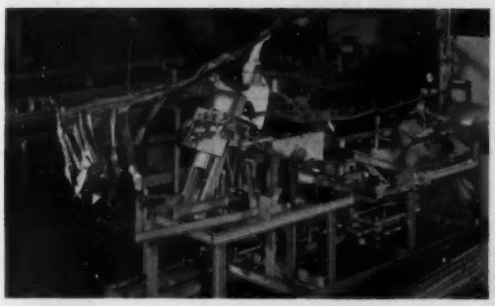
TITLE_____

ATTACH TO YOUR COMPANY LETTERHEAD AND MAIL TODAY!

TRAPPED BY TUBING PROBLEMS?



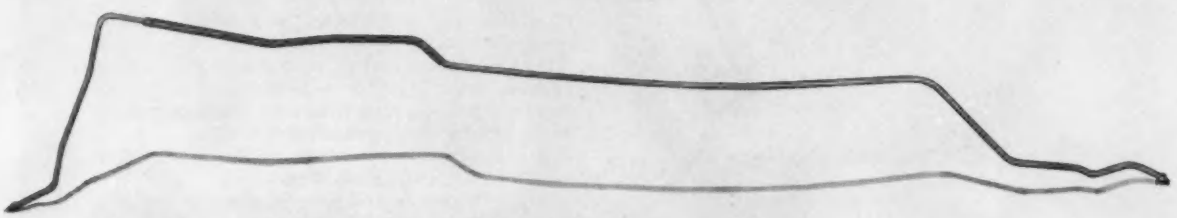
LINES FORMED RIGHT...
WITH GM STEEL TUBING AND UNEQUALED FABRICATION FACILITIES!



Rochester Products' many hydraulic forming fixtures turn out a fast, uniform flow of GM Steel Tubing fuel lines.

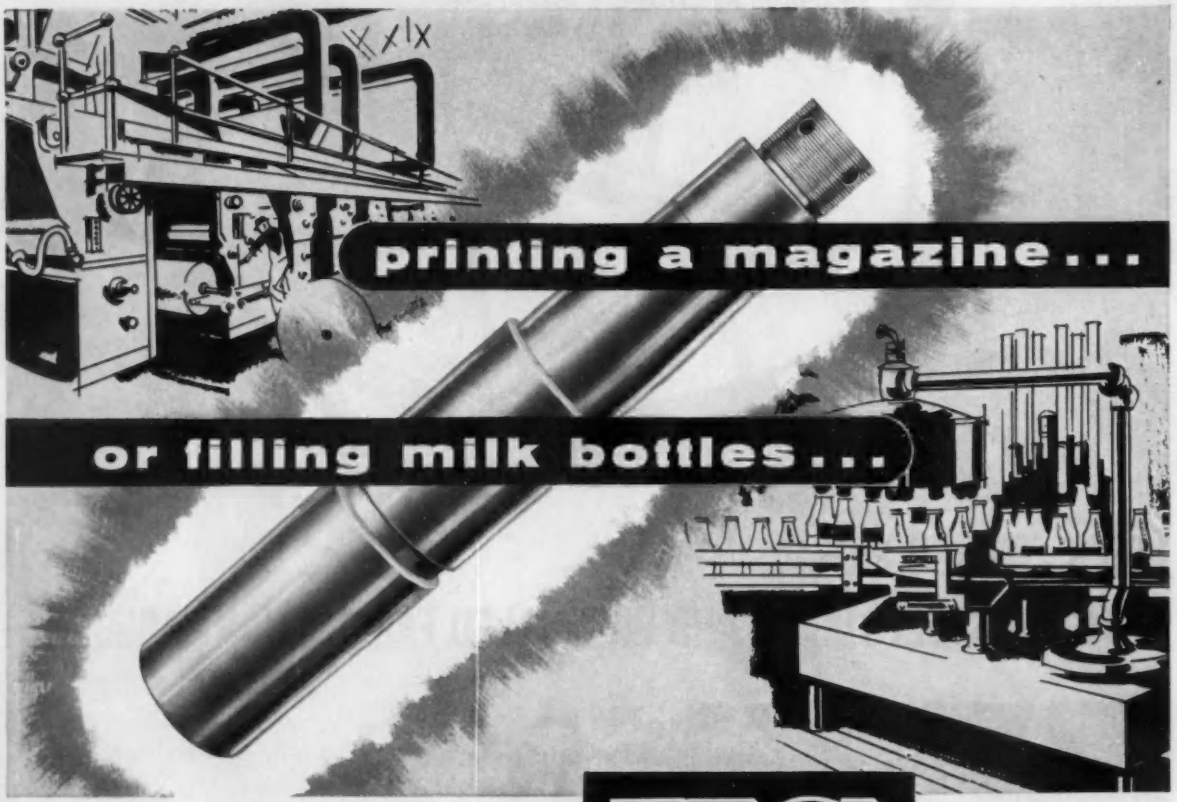
Fuel lines . . . oil lines . . . brake lines come *right* from Rochester! The industry's finest equipment forms, fits and fabricates these and other intricate assemblies for America's finest cars.

Rugged, reliable GM Steel Tubing performs its way into more new products every day. Tubing quality, engineering capability and production facility form a cost-cutting, schedule-saving line-up that's ready to go to work for you! Call your Rochester Products Sales Engineer or write us direct.



GM STEEL TUBING BY ROCHESTER PRODUCTS

ROCHESTER
PRODUCTS
DIVISION OF
GENERAL MOTORS
ROCHESTER N.Y.



THE WHEELS OF INDUSTRY TURN ON

US AXLE SHAFTS

Out in the field and inside the plant, wherever there's work to be done, you'll find labor-saving and time-saving machines. And wherever you find machines, you'll find U.S. Axle Shafts in every size and description, making their contribution toward smooth, trouble-free performance.

U.S. Axle Shafts are made of the finest alloy steel, heat-treated, and then shot-peened — the hardening process that makes U.S. Axles up to 5 times tougher —by actual torsion tests. We will be happy to use our 36 years of engineering skills to help you improve *your* product performance.



Call on U.S. AXLE for shafts for every application



FREE VALUABLE BROCHURE

Shows you why U.S. Axle is your best source for precision-made special shafts.

THE U. S. AXLE COMPANY
Pottstown, Penna.

Please send me the brochure on "U.S. Custom-Engineered Shafts."

Name_____

Firm_____

Address_____

City_____ Zone____ State_____

"THE WORLD TURNS ON U. S. AXLES"

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Since 1920 • Pottstown, Pennsylvania

FOR *EXTRA* SAFETY . . .

MEET THE NEW ICC REGULATIONS WITH MIDLAND EQUIPMENT!



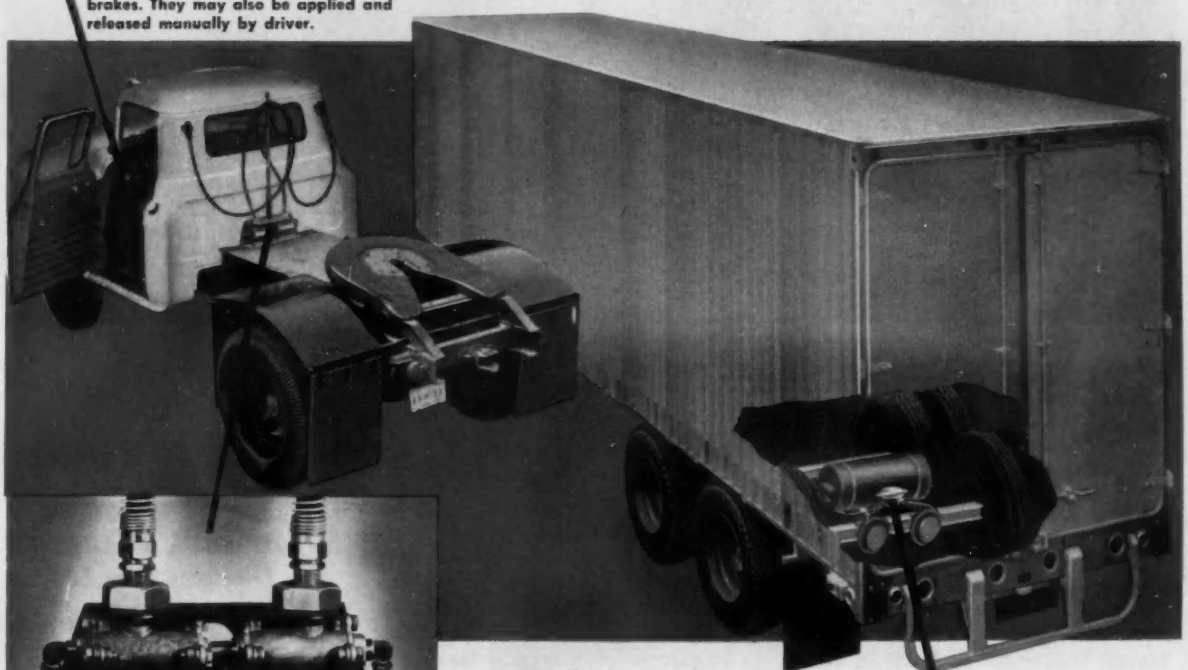
Dash hand valve is automatic and manual, functioning as a part of Midland's breakaway system. If emergency line pressure goes below 40 PSI, it automatically applies trailer brakes. They may also be applied and released manually by driver.

Midland's tractor-trailer braking system is designed for the ultimate in braking protection. With this new system (1) tractor protection is AUTOMATIC, so important in split-second emergencies; (2) valves are large-capacity, giving you faster, more positive action; (3) you have a *combination* manual and automatic dash control valve for *instantaneous* application and release of trailer brakes; (4) manual shut-off cocks are eliminated . . . Specify Midland Power Brakes for extra quality performance, more positive protection. Make it Midland, too, when replacing or modernizing the braking system on your present equipment. Your nearest Midland distributor is anxious to serve you. Just give him a call.

THE MIDLAND STEEL PRODUCTS CO.

6660 MT. ELLIOTT AVENUE • DETROIT 11, MICHIGAN

Export Department: 38 Pearl Street, New York, N.Y.

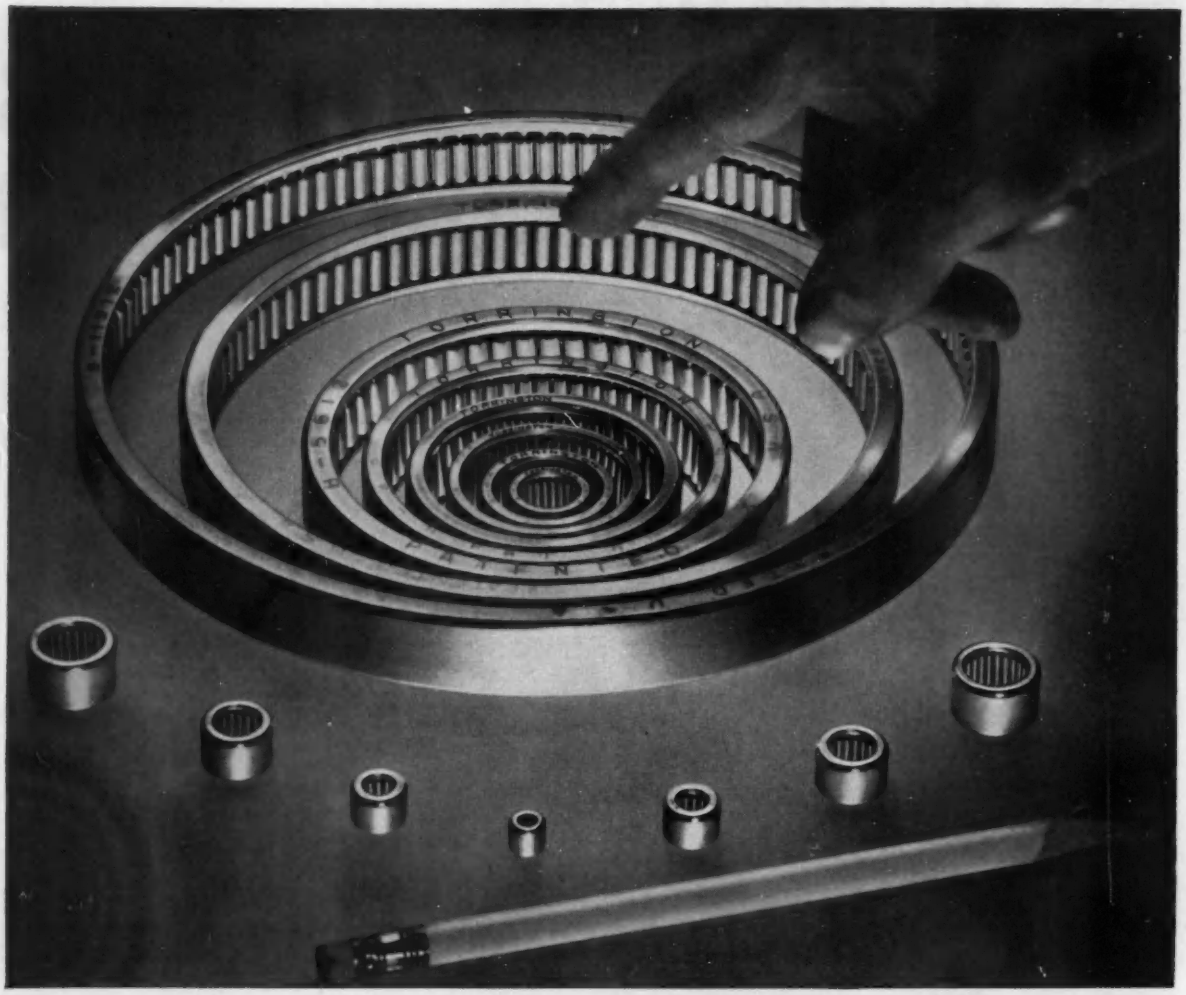


Automatic shut-off valves eliminate hand-operated shut-off cocks and function as part of the Midland breakaway system to retain adequate tractor pressure for breakaway protection.

Midland's new air emergency relay valve meets the "no feed back" requirement. Designed to reduce application and release time. Safeguards against vehicle driveaway without sufficient air in the system.



GO MIDLAND — AND STOP SAFELY!



TORRINGTON NEEDLE BEARINGS

come in large sizes too!

Meeting the needs of designers for more compact, higher capacity anti-friction bearings in thousands of applications, Torrington Needle Bearings are made in a range of sizes for shafts from ⅛" up to 7¼" in diameter. Several widths are available in most sizes to meet different application requirements.

In the large sizes as in the small, basic design advantages are the same. Unit cost is low and radial load capacity is greater than any other anti-friction bearing of the same size.

Large Needle Bearings are doing big jobs in transmissions, steering gears, suspension and starting motors of farm tractors and earth-moving machinery. They have also been used for many years in industrial hydraulic pumps.

To gain the advantages of the unique Torrington Needle Bearing in your product, enlist the knowledge and skill of our Engineering Department.

See our New Needle Bearing Catalog in the 1956 Sweet's Product Design File —or write direct for a catalog.

TORRINGTON NEEDLE BEARINGS
Give you these benefits

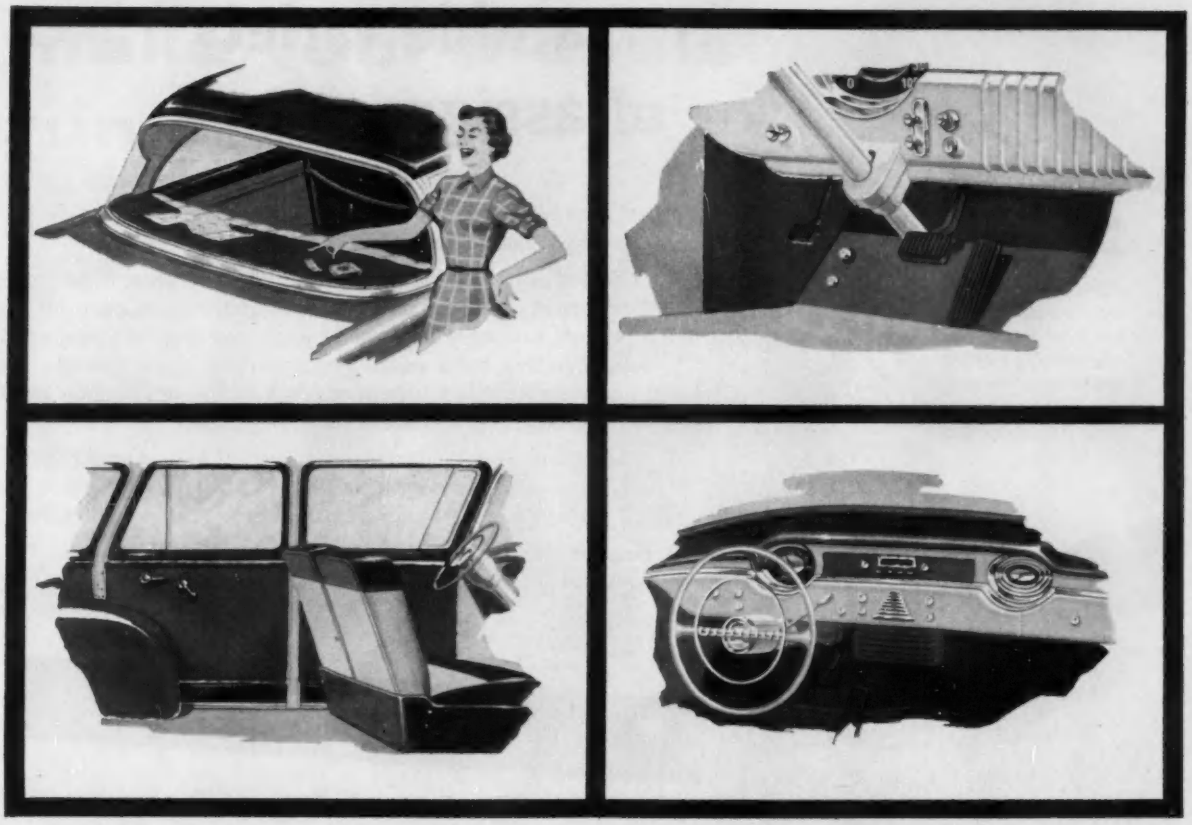
- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Naugatuck Marvibond



vinyl-to-metal... laminated before forming

MARVIBOND† is Naugatuck's patented laminating process that permanently bonds MARVINOL® vinyls to practically any sheet-metal *before the product is formed*. Bonded in flat sheets or coils on a continuous production basis, Marvibonded laminates can be bent, crimped, drilled, punched, or deep-drawn without fracturing the finish – without weakening the adhesive. And they're available in practically any surface effect!

Chemical, abrasion and weather resistant, Marvibonded metals provide your product with a finish far superior to paints, lacquers, varnishes, phenolic and alkyd finishes, as well as upholstered ones. Scuff-marks, fingerprints and stains wipe off with a damp cloth.

This exceptional material can be used economically everywhere that sheet metal is used... dashboards, window trim, door panels, kick panels, truck cabs and other interior automotive components. For technical data, samples and the names of licensed laminators in your area write to us on your company letterhead.

†U. S. Pat. No. 2,728,703

United States Rubber

Naugatuck Chemical Division

Naugatuck, Connecticut

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IN CANADA: Naugatuck Chemicals, Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N. Y.

to the Engineer who seeks a wide variety of assignments

To non-aircraft engineers:

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering – at full pay.

An unparalleled variety of assignments awaits you at Lockheed's Engineering Flight Test Division.

Lockheed diversification is the reason. This year alone flight tests must be conducted on new turbo-compound and prop-jet transports, extremely high-speed fighters, new types of jet trainers, patrol bombers, radar search planes and aerological aircraft. In development are jet transports and nuclear applications to aircraft and a large number of classified aircraft.

You not only work on many types of aircraft in Lockheed Flight Test, your work within each plane varies widely. Each flight test presents new problems, frequently requires new approaches.

Because of this, personal initiative is welcomed and rewarded at Lockheed.

Assignments are in fields of:

POWER PLANT: engine and after-burner; fuel systems; oil, fire extinguishing and air conditioning systems.

FLIGHT ANALYSIS: CAA certification, aerodynamic performance, data processing.

STRUCTURAL FLIGHT MEASUREMENT

INSTRUMENTATION: systems design, calibration and maintenance.

WEAPONS: fire control systems, ordnance, rocket sleds.

RADIO AND RADAR: communications, search radar, magnetometers, ranging and sighting gear.

DYNAMICS: flutter, sound, vibration, autopilot and approach systems.

Positions are open for:

AERONAUTICAL ENGINEERS
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ELECTRICAL ENGINEERS
PHYSICISTS
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CIVIL ENGINEERS
with and without aircraft experience
AIR TRANSPORT OPERATIONS ENGINEERS

Brief résumé form at right is for your convenience in contacting Lockheed.

E. W. Des Lauriers, Dept. 1604
Lockheed Aircraft Corporation
Burbank, California

California Division

Lockheed

Lockheed Aircraft Corporation
Burbank **California**

Name

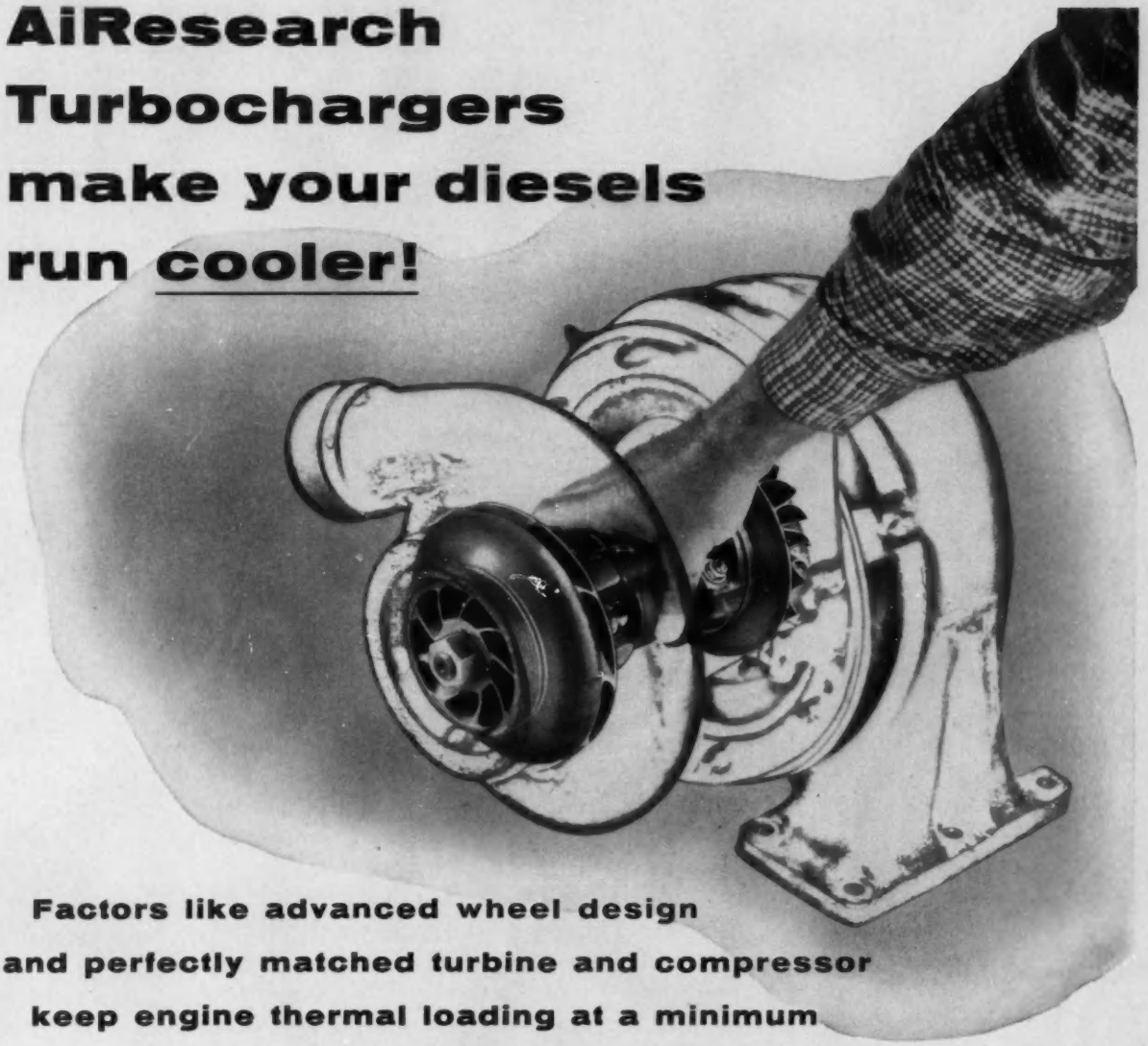
Field of engineering

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AiResearch Turbochargers make your diesels run cooler!



Factors like advanced wheel design and perfectly matched turbine and compressor keep engine thermal loading at a minimum

So effective is the AiResearch turbocharger that it provides power gains while actually lowering the heat level of the engine.

Ambient air is compressed with an efficiency as high as 82%, feeding a maximum weight of air into the cylinders at the lowest possible temperature.

Results: maximum power gain at minimum fuel cost; complete combustion with elimination of objectionable smoking; low engine thermal loading insuring long, trouble-free operation.

All AiResearch turbochargers are air cooled, placing no added burden on the diesel cooling system and requiring no complicated plumbing. The rotating assembly is removable as a unit, simplifying in-the-field maintenance. This advanced design evolved from the most extensive experience in the field of small turbomachinery in America.

Your inquiries are invited.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS

MODEL	F-51	C-60	A-60	E-100	B-100
Diameter — in. nom.	9	11.5	15.25	15.25	16
Length — in.	9	14.12	16.75	17.25	21.75
Weight — lb.	40	95	125	135	195
Output — lb/min. (Standard Conditions)	25-40	35-65	35-65	70-95	115-175

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

XX

This is the twentieth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Flame-Hardening Alloy Steels

When the surface of steel is subjected to direct application of flame and heated above the transformation range, then hardened by quenching, the process is known as flame-hardening. Its primary purpose is to surface-harden without affecting core properties. Jets of flame are played directly on the steel, and hardness penetration can be made to vary considerably. Usually in alloy steels this depth will range from 0.03 to 0.12 in., the actual figure depending upon the method of heating and quenching used.

Unlike carburizing, flame-hardening does not involve the absorption of extraneous elements by the steel. There is no alteration of the chemical composition. To put it simply, the steel must have its own self-hardening characteristics; cannot be dependent upon carbonaceous salt baths, gases, etc.

Flame-hardening is not a substitute for the conventional furnace method. Each has its uses. The particular virtue of flame-hardening is that the flames can be directed to localized areas. The furnace, on the other hand, is generally more economical and feasible when parts produced in large quantities must be hardened all over.

Any type of hardenable steel, alloy or carbon, can be flame-hardened, and there will usually be no scale or pitting. The alloy content is the governing factor when determining the quench. In some cases a rapid quench is required; in others, it can be as slow as air-cooling. Tempering presents no problems, for flame-hardened steel can be tempered as if hardened to the same point by other methods.

A list of typical flame-hardened parts would include such familiar items as gear and sprocket teeth, and certain types of cams and rollers, shoe treads, etc. This list is by no means exhaustive; it could include many other parts that often require a localized hardening treatment, especially for wear-resistance.

When seeking information about flame-hardening methods, please feel free to consult with our technical staff. Bethlehem metallurgists will gladly cooperate, and you can depend upon their suggestions. You can rely on Bethlehem, too, as a source of alloy steels, for Bethlehem makes the complete range of AISI standard grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through No. XVI, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa. The first 16 subjects in the series are now available in a handy 32-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

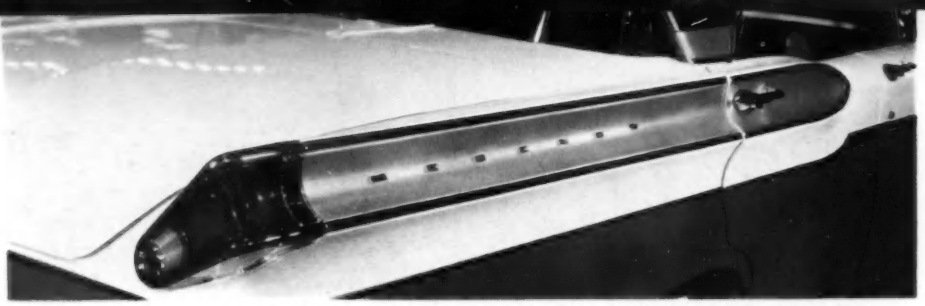
BETHLEHEM STEEL

BETHLEHEM STEEL



The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM THE BIG M

The magnificent Mercury Turnpike Cruiser—the top of the Big M fleet—features the gleam of gold anodized aluminum inside and out. The "M" front emblem, "Turnpike Cruiser" script, rear fender projectile applique, roof side ornament, "Keyboard Control" automatic transmission selector plate, front seat side shield insert and inside door handle escutcheons are all gold anodized aluminum. Scuff plates are natural finish aluminum. We are proud to be a supplier of sales appealing automotive parts like these.



Rear fender projectile applique—fine hex embossed aluminum sheet, gold anodized.

Plan on Aluminum

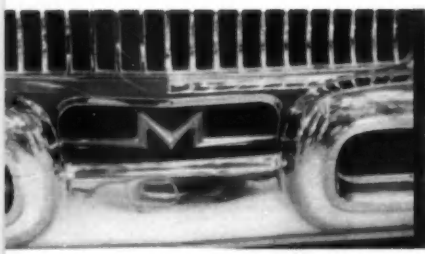
parts and trim . . . for lasting beauty, sales appeal and fabricating economy

There's more aluminum than ever before in the fine new '57 cars. That's because aluminum adds so much more sales appeal . . . adds dash and flair and brilliance . . . adds *value*.

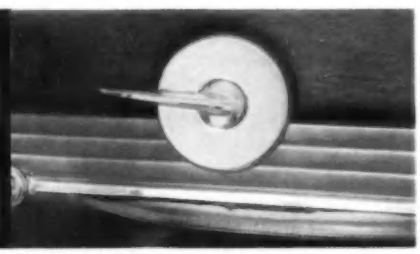
You see this trend to aluminum in *color anodized* aluminum grilles, side-sweep moldings, wheel covers, emblems and other parts with the "gleam of gold" or other colors. And you see it in *clear anodized* aluminum parts with their mellow luster—the "look of sterling". This beauty lasts, too, because anodizing is the in-the-metal finish that will not pit, chip, flake or tarnish—ever.

Aluminum also lowers costs and improves performance—for electrical parts, pistons, transmissions and other hidden parts. That's because aluminum is low in cost, easy to fabricate, lightweight yet strong, free from rust, offers high electrical and thermal conductivity.

Reynolds Aluminum Styling and Engineering Specialists will be glad to work with you to help you get the very best from the aluminum you use. For details, call the Reynolds Office listed under "Aluminum" in your classified telephone directory. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan* or *Post Office Box 1800-MZ, Louisville 1, Kentucky.*



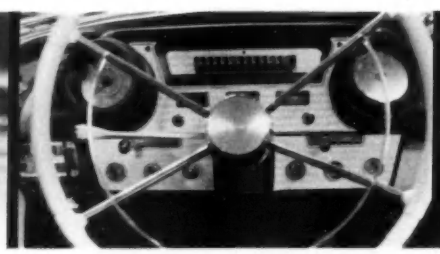
Big "M" emblem—stamped from aluminum sheet, gold anodized.



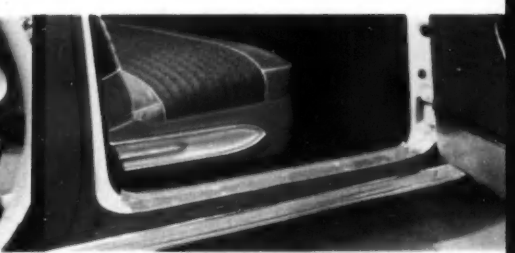
Inside door handle escutcheon—stamped from embossed aluminum sheet gold anodized.



Roof side ornament—fine hex embossed aluminum sheet inserted in die casting, gold anodized. Turnpike Cruiser script—coined aluminum sheet, gold anodized.



"Keyboard Control" automatic transmission selector plate and instrument panel—stamped from aluminum sheet, pattern mechanically applied.

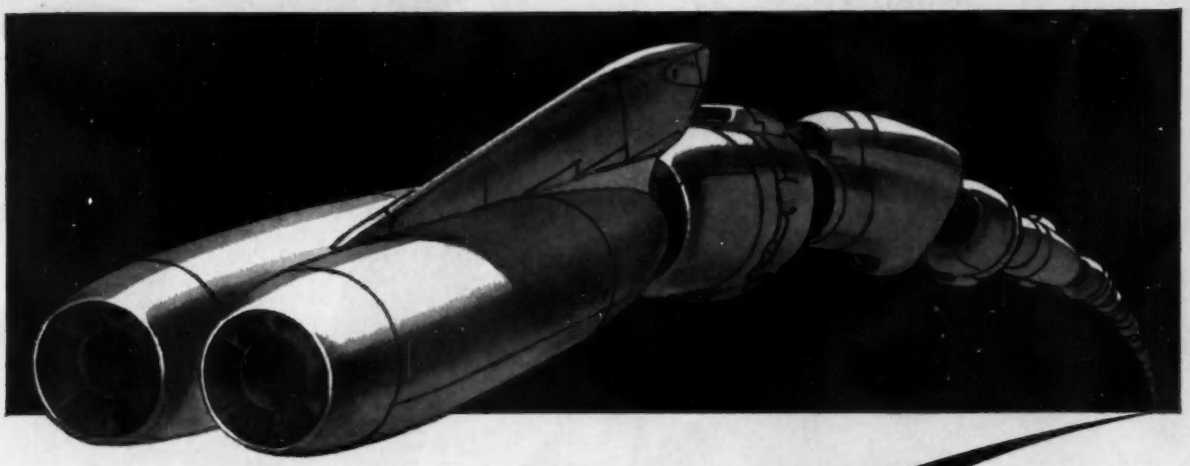


Front seat side shield insert—fine hex embossed aluminum sheet, gold anodized. Scuff plates—stamped from aluminum sheet, natural finish.

REYNOLDS ALUMINUM

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

See "CIRCUS BOY", Reynolds dramatic series, Sundays on NBC-TV



ROHR HAS BUILT MORE THAN

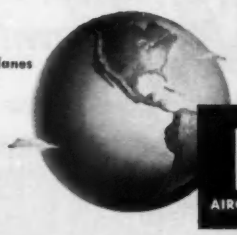
200 MILES OF POWER PACKAGES

More than 56,000 complete, ready-to-install power packages for most of America's leading commercial and military planes have been designed and built by Rohr.

Consider this wealth of design and production experience! Today this experience is evident in over 30,000 different Rohr-built parts for aircraft of all kinds.

Next time — look to Rohr!

World's Largest Producer of Ready-to-Install Power Packages for Airplanes



ROHR
AIRCRAFT CORPORATION

Excellent career openings for engineers and skilled technicians

CHULA VISTA, CALIFORNIA

Also plants in Riverside, California; Winder, Georgia; Auburn, Washington



...BOHN'S 40 years experience producing castings, forgings and extrusions assures you:

- A DEPENDABLE SOURCE of production materials
- QUALITY CONTROL through every phase of production
- ENGINEERING SKILL to solve customer problems
- PRECISION PARTS made to rigid tolerance requirements
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- PERSONALIZED SERVICE with prompt, accurate quotations

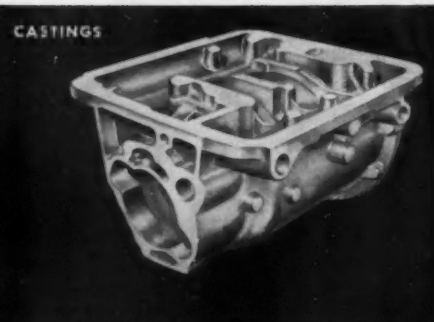
BOHN

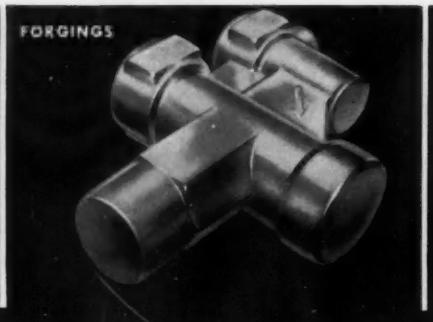
SALES OFFICES: *Boston • Chicago • Cleveland • Dayton • Detroit • Indianapolis Milwaukee • Minneapolis • Moline • New York • Philadelphia • Rochester • St. Louis*

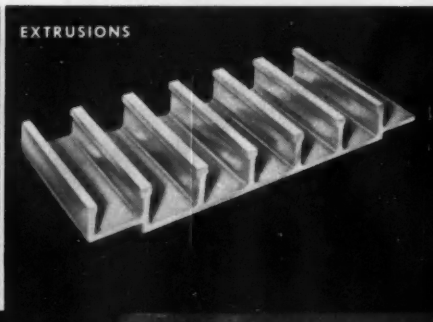
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- Assistance in establishing advanced objectives for engine and component objectives

Requirements: B.S., M.S., or Ph.D. degree in either Mechanical or Aeronautical Engineering, plus six or more years' experience in propositions writing or a related field

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Professional Placement

JET ENGINE DEPARTMENT
Bldg. 500, Room 138

GENERAL ELECTRIC

Cincinnati 15, Ohio

"There will always be a frontier

where there is an open mind and a willing hand. You can't walk without stumbling over opportunities," says CHARLES FRANKLIN KETTERING, "Boss Ket," who has followed this creed for 80 amazingly productive years.

Professional Amateur



The Biography of
CHARLES FRANKLIN KETTERING

By T. A. Boyd

Introduction by Alfred P. Sloan, Jr.

Inventor, engineer, humanitarian, philanthropist, philosopher, "Boss Ket" has lived the American dream. It was his vision, faith, and inventive genius which gave us the self-starter, the electric cash register, "Ethyl" gasoline, the new type diesel engine, high octane fuel, and which today, through the Sloan-Kettering Institute, is tirelessly searching for a cancer cure.

How this modern-day Ben Franklin rose from farm boy to head of General Motors' Research and achieved fame and fortune in the great American tradition is an inspiring story, filled with all the color, drama and excitement of this country's wonderful pageant of progress in the twentieth century.

Every engineer will find in this book an inspiration to greater accomplishments.

Illustrated. $4.50

Mail this coupon for your copy today

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Please send me _____ copies of PROFESSIONAL AMATEUR @ $4.50.
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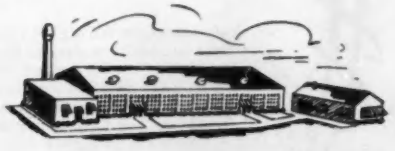
Quality Control Counts!

Manufacturing growth usually depends on one prime ingredient . . . *performance!* In the field of vinyl resin coated fabrics, ATHOL is proud of their continuing ability to provide consistent, reliable quality in accordance with *exact specifications.*

It is ATHOL'S many years of experience and never-ending pioneering in the coated fabric field, *plus* the technical skill developed from servicing some of the largest users in the country, that has resulted in our present highly expanded production facilities.

Your inquiries are invited.

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Represented on the Pacific Coast by A. B. Boyd Co.
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Athol, Mass.
and Butner, N. C.

VINYL FABRICS FOR AUTOMOTIVE USE

ERMETO®



ERMETO 8000 SERIES
Steel or stainless steel fittings in sizes and types to meet any need. No flaring, threading, welding or soldering.

ERMETO 7000 SERIES
Meets new S.A.E. Boss specifications. Permits closer couplings, higher pressures. New Weathercote finish resists corrosive elements.

UNMATCHED FOR POSITIVE HIGH PRESSURE CONTROL

Introduced by Weatherhead nearly a quarter century ago, Ermeto continues to top the list as industry's most popular high pressure flareless tube fitting. Assures better service in every field where hydraulic power is applied. Distributors coast to coast.

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FIRST IN HYDRAULIC CONNECTIONS

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Work on such advanced problems as how to develop a gas turbine with a power weight ratio of more than 4 to 1. It involves the design of a variety of static and moving parts; compressors, combustors, turbines, control components, gear and lube systems.

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This is a young decentralized department where an able man may quickly advance to a position of responsibility. Professional development program — extensive educational facilities. Location: New England.

Write in confidence to:
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485 LEXINGTON AVE., N. Y.



The new Wooldridge "Cobrahaul" Rear Dump Unit with Fuller 9-speed R-1150 ROADRANGER Transmission.

FULLER R-1150 ROADRANGER® Transmission standard on new Wooldridge "Cobras"!

The Fuller 9-speed R-1150 ROADRANGER Transmission is *standard equipment* in the new Wooldridge 35-ton, 275 hp diesel "Cobrahaul" Dumper and 26-yard 300 hp diesel "Cobra Quad" Scraper. Haul speeds exceed 32 miles an hour on the big 63,400 lb. unit.

Throughout the complete Wooldridge line . . . from the giant 41-yard scrapers down to and including the 7.5-to-10-yard "Cobrette," Fuller Transmissions are standard on Wooldridge Scrapers and hauling units.

Why? Only the most rugged, dependable transmissions can take the terrific shock loads—sudden starts—stops—torque reversals found in all kinds of off-highway operations from solid rock hauling to soggy swamp jobs.

Fuller Transmissions provide maximum ease of shifting ratios for faster acceleration and long life required for these operating conditions.

In Wooldridge's "Cobrahaul" and "Cobra Quad," the Fuller R-1150 ROADRANGER Transmission offers these additional advantages:

- **No gear splitting—9 selective gear ratios evenly and progressively spaced**
- **Easier, quicker shifts—38% steps between ratios**
- **One shift lever controls 9 forward and 1 reverse speeds**
- **Engines work in peak hp range with greater fuel economy**
- **Less driver fatigue—⅓ less shifting**
- **Range shifts pre-selected—automatic and synchronized**

From over 110 models available for rubber-tired equipment, there's a Fuller Transmission designed to do your job.

really **where horsepower goes to work**



Fuller TRANSMISSIONS®

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO, MICHIGAN

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Linkage

The Long and Short of it . . .

HEIM *Unibal* Rod Ends

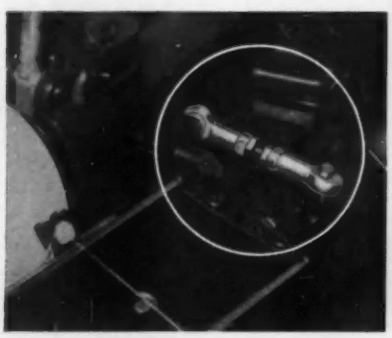
make an Infinitely Adjustable Linkage

For a short connecting rod, an externally threaded male Heim rod end can be screwed into an internally threaded female rod end to give smooth transmission of power or force.

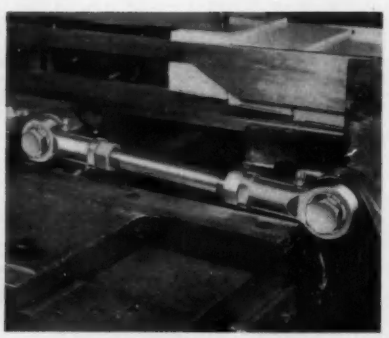
Longer connecting rod assemblies are just as simple to make by using the proper length of tube or rod between Heim rod ends.

The push-pull rods or linkages can be assembled by riveting, by swaging, by welding, or by threading and locking with set screws or lock nuts.

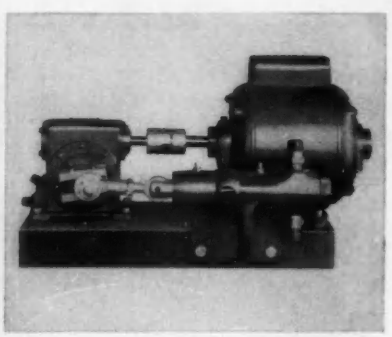
Heim Unibal Rod Ends are self-aligning, they reduce friction and lost motion, and they are economical in price and in installation time.



A short length of rod, threaded at both ends to fit two Heim Unibal female rod ends, is used on this Foster Machine Co. Model 75 pineapple coning machine. This machine is used for winding nylon, and rayon yarns to packages for use on full fashion knitting machines.



A longer length of rod, with two Heim Rod Ends locked in position with hex nuts, actuates the feed on this cartoner made by R. A. Jones & Co. Jones Constant Motion Cartoners handle millions of bottles, jars, tubes, etc. every day in a wide variety of packaging.



A male Heim rod end screwed into a female rod end forms the short linkage necessary on this Milton Roy pump. The self-aligning feature of Heim Unibal corrects the misalignment between the crank arm and the plunger moving in the pump frame.

The Heim engineering department will be glad to assist in solving your linkage problems. The Heim catalog should be at your fingertips. Please write.

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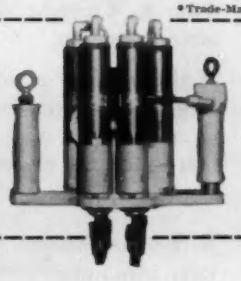
- Handles drills up to ⅜".
- Positive differential lead screw prevents plunging on break-through.
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- Drills so cleanly that reaming is often unnecessary.
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- Instant bit return prevents damage during drilling cycle.
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For complete information and specifications, write Gardner-Denver Company—Keller Tool Division, Grand Haven, Michigan.

*Trade-Mark

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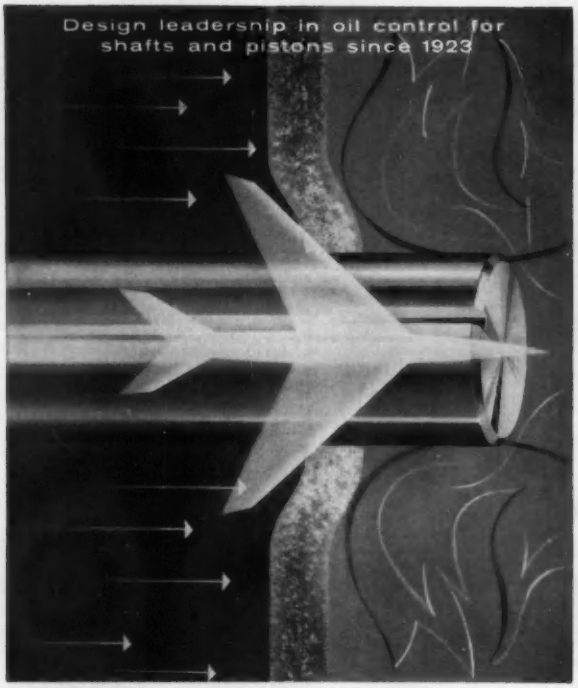
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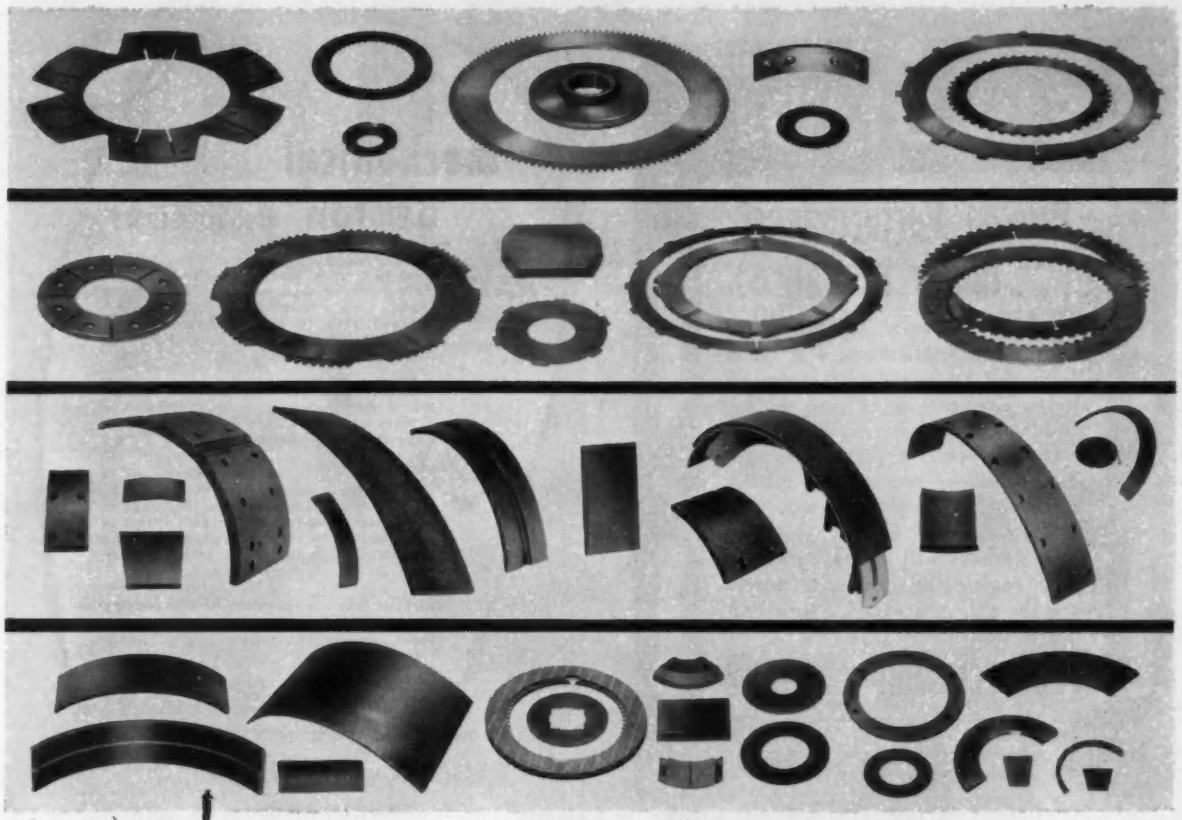
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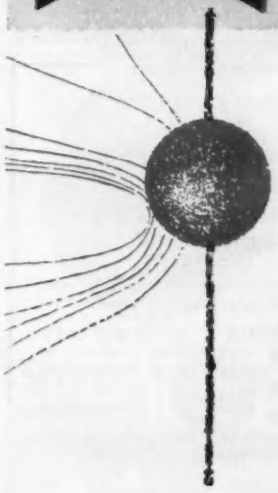
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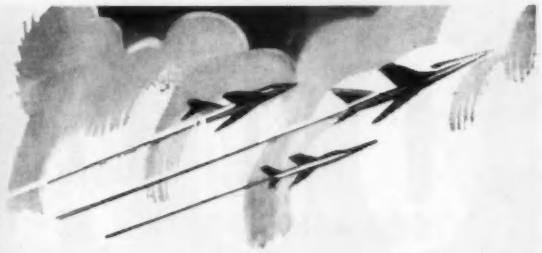
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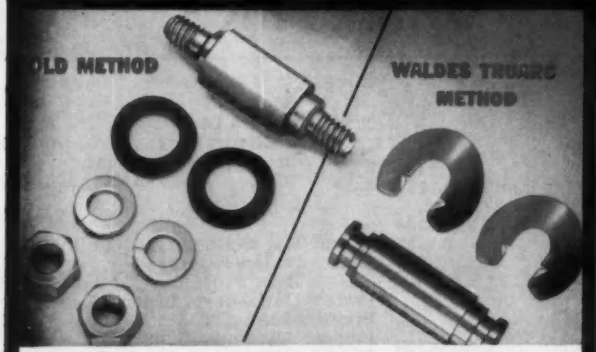
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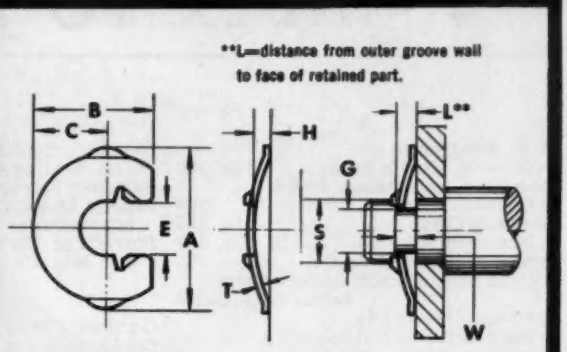
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★15	.156	±.003	.380	±.010	.330	±.010	.184	±.005	.108	±.004	.055	±.010	.010	±.0013	600	.104	±.002	.050	+.005	.035	.045	.010
18	.188	±.003	.445	±.010	.390	±.010	.213	±.005	.130	±.005	.060	±.010	.015	±.0015	900	.124	±.002	.065	+.005	.045	.055	.010
25	.250	±.003	.581	±.010	.500	±.010	.280	±.005	.172	±.005	.070	±.010	.015	±.0015	1000	.165	±.002	.070	+.005	.050	.065	.015
31	.312	±.003	.744	±.010	.620	±.010	.360	±.005	.234	±.005	.095	±.010	.018	+.001 –.002	1300	.228	±.003	.080	+.005	.080	.095	.015
★37	.375	±.003	.853	±.015	.740	±.010	.427	±.005	.280	±.005	.130	±.010	.020	±.002	1900	.270	±.003	.105	+.005	.090	.115	.025
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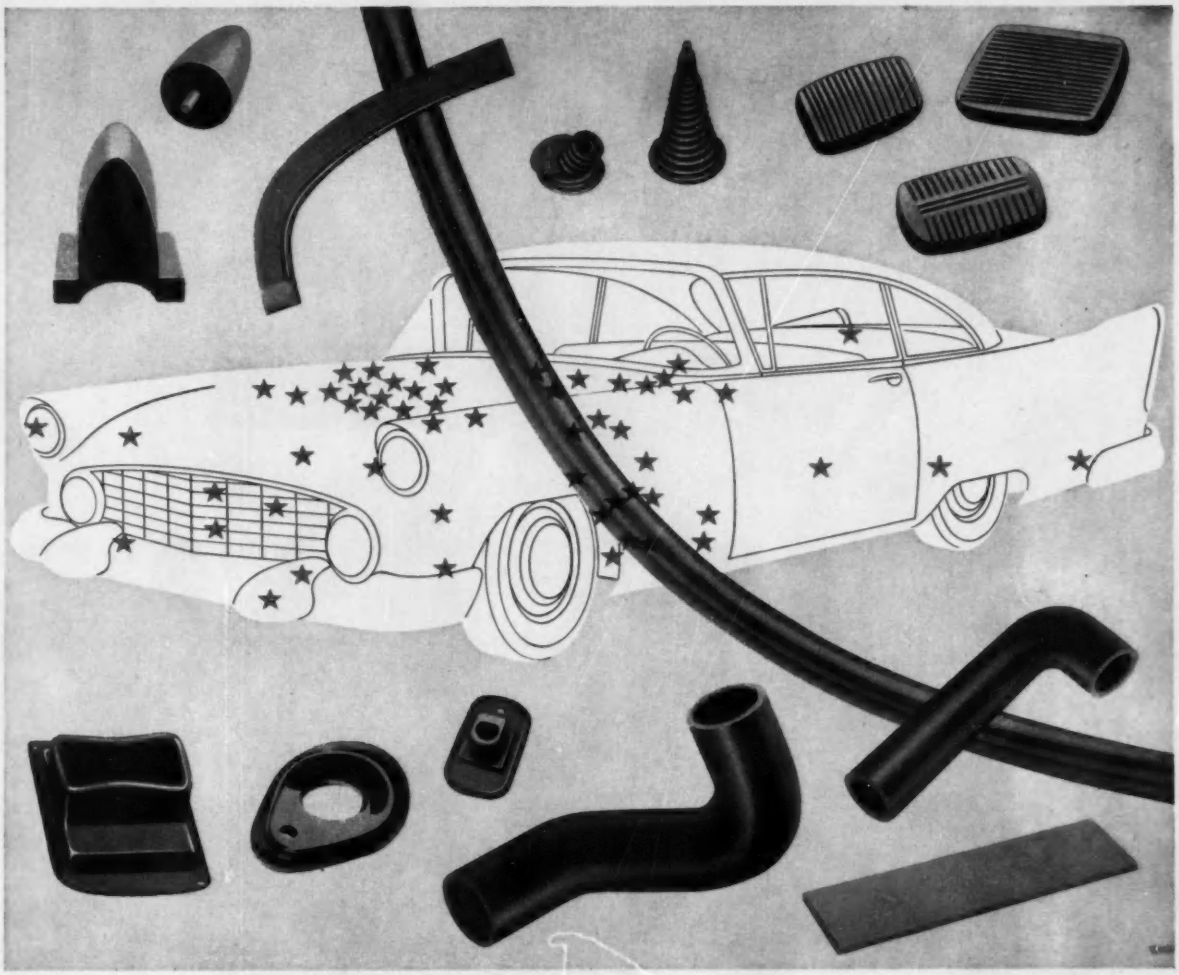
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A SWIRL OF OIL SLOWS THIS BABY TO A WALK

without riding the brakes



New TORQMATIC *FourSpeed is the only torque converter, four-speed full-power shift transmission and hydraulic retarder designed in one compact unit for logging.*

This new transmission solves logging problems like a quiz kid in a bookstore. For instance:

DOWNHILL HAULS—save brakes for snubbing and stopping. Just pull the hydraulic retarder lever. The harder you pull—the slower your descent. It's done with oil—inside the TORQMATIC FourSpeed.

TROUBLESOME RETURN TRIPS—time was, an engine would be "wound up tight" all the way back with no load. Now the fourth gear in TORQMATIC FourSpeed is a high-speed overdrive for smooth sailin' coming home.

NO MISSED SHIFTS—this baby shifts at full throttle with no strain. You just pour on the coal—TORQMATIC FourSpeed does the rest. She's rated at 350 horsepower, so don't be afraid to stand on it. We built TORQMATIC FourSpeed for big trucks with big jobs.

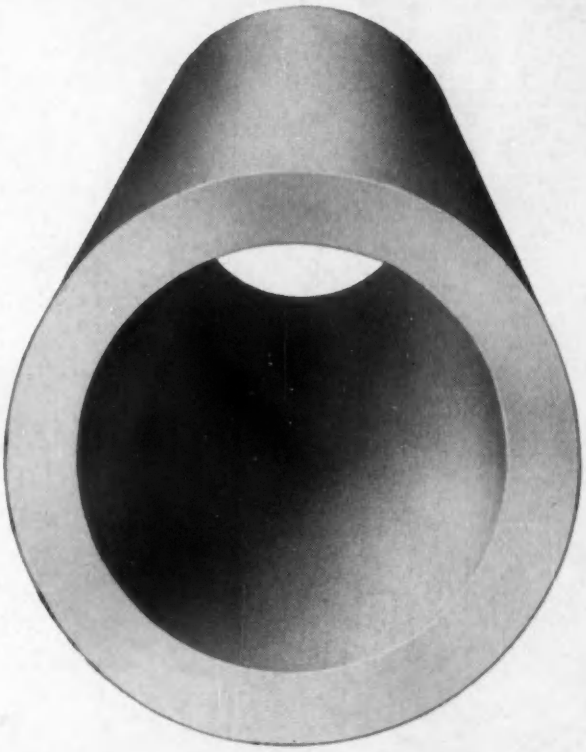
THIS ONE PAYS ITS OWN WAY—in brake linings alone, you'll save the cost of TORQMATIC FourSpeed. Here's the proof of that—one log hauler used 170 gallons of water cooling brakes every trip. With TORQMATIC FourSpeed, only 40 gallons a trip. That, sir, is 77% fewer brake applications.

So add it up. TORQMATIC FourSpeed will pay for itself, and do a better job of log hauling, too. Get the full story from your equipment supplier, or write: ALLISON DIVISION OF GENERAL MOTORS, Box 894X, Indianapolis 6, Indiana.

Allison TORQMATIC DRIVES

GM TORQMATIC

How to step up production of hollow parts



Start with TIMKEN® seamless steel tubing—*no hole to drill!*

MAKING hollow parts from bar stock slows down production. You have to bore out the center hole. That takes extra time, increases production costs. But with Timken® seamless steel tubing, *the hole's already there.* Finish boring is your first production operation. You save a big step—increase production, reduce costs. With less metal to machine away you get more parts per ton of steel.

Because Timken seamless steel tubing eliminates one boring operation, it frees screw machine stations for other jobs. You add machining capacity without adding machines.

Timken seamless tubing also gives you a better quality finished product. The piercing process by which Timken seamless tubing is made is basically a forging operation. It gives you fine forged quality—a uniform spiral grain flow for greater strength and a refined grain structure. And we maintain this uniform quality through rigid quality control—tube to tube, heat to heat, order to order.

And to further increase your steel savings, Timken Company engineers will recommend the most economical tube size for your hollow parts job—a size guaranteed to clean up to your dimensions.

The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING